MATHEMATICS TEACHERS' CLASSROOM PRACTICES IN THE CONTEXT OF 21st Century Skills: A CASE OF ONE SECONDARY SCHOOL IN LUSAKA DISTRICT, ZAMBIA.

By

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DECLARATION

I, **Chantell Bwalya Chileshe** do declare that this dissertation was solely done by me and that it has never been submitted for examination in any other college or university and that all the sources I have used have been fully acknowledged. I further declare that the views and opinions contained in this dissertation do not in any way represent those of University of Zambia, but my own.

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CERTIFICATE OF APPROVAL

The University of Zambia approved the dissertation of **Chantell Bwalya Chileshe** as a partial fulfilment for the award of the degree of Master of Education in Mathematics Education.

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ABSTRACT

Despite global aspirations towards a 21st Century Skills learning agenda, Zambia's efforts to effectively integrate these skills into classroom settings have shown limited advancement. This discrepancy highlights the challenge of translating theoretical aspirations into tangible educational practices. It is in this light that the researcher investigated the mathematics teachers' classroom practices in the context of 21st Century Skills at secondary school level. Mathematics teachers' practices were focused on because mathematics as a subject plays a key role in shaping how individuals deal with the various spheres of life, be it private, social or cooperate. The objectives of this study included: determination of what mathematics teachers know about 21st Century Skills; determination of how mathematics teachers' classroom practices align with facilitation of learners' acquisition of 21st Century Skills; understanding ways in which classroom-based assessments as administered by mathematics teachers are aligned with 21st Century Skills; and establishment of the views of teachers on the challenges they face in line with the 21st Century Skills. In this qualitative study, an ethnographic research design was utilized. The study sample consisted of two secondary school mathematics teachers who were purposively selected. The first teacher had 29 learners whereas the second one had 24 learners. Semi-structured interviews, lesson observations, performance assessment and document analysis were used to generate information. Content analysis was employed to analyze the collected data. It was found out that the sampled teachers were aware of 21st Century Skills however they deemed technology as the main 21st century skill. The teachers practices in respect of teaching and assessment did not incorporate strategies aligned to the learner acquisition of the 21st Century Skills, an occurrence which denied learners to effectively acquire the 21st Century Skills focused on in this study. Consequently, it is recommended that school mathematics departments implement comprehensive professional development programs for mathematics teachers that encompasses 21st Century Skills beyond technology. Furthermore, professional development programs should integrate innovative teaching strategies and align classroom assessments with 21st Century Skills.

Key words: 21st Century Skills, mathematics teachers' classroom practices, learner performance assessment

DEDICATION

This work is dedicated to my father Justin Bwalya Chileshe, my mother Merit Mafoti and my sister Vanessa Bwalya Chileshe for the continued support throughout this academic journey. I also dedicate this work to my aunt and sponsor Bertha Musonda Chileshe for unwavering guidance and support. With their insightful vision I have been able to fulfil this achievement.

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ACRONYMS AND ABBREVIATIONS

ANCOVA	Analysis of Covariance
4Cs	Learning and Innovation Skills: communication, collaboration, creativity and critical thinking
CTM	Constructivist's Teaching Method
CISCO	Computer Information System Company
DA	Data Analysis
DCIQM	Difficult Concept Identification Questionnaire in Mathematics
2D	Two Dimensions
3D	Three Dimensions
ECD	Evidence Centered Design
ESSP	Educational and Skills Sector Plan
HOTS	Higher-Order Thinking Skills
ICT	Information and Communication Technology
IL	Information Literacy
OECD	The Organization for Economic Cooperation and Development
P21	Partnership for 21st Century Skills
PISA	Programme for International Learner Assessment
PD	Professional Development
SDG	Sustainable Development Goals
SNM	Science News Media
STEM	Science Technology Engineering and Mathematics
T&L	Teaching and Learning
TOUCM	Test on Understanding of the Concept of Mensuration
US	United States

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the background to the study and statement of the problem. It further looks at the purpose of the study, research objectives and research questions that needed to be addressed. It also includes the significance of the study, theoretical and conceptual framework, scope of the study and limitations. The chapter also contains operational definition of key terms and ends with a summary of the chapter.

1.2 Background of the study

In education distinctively, there is the concern of a global learning crisis that learners are not fully prepared with the skills they need to thrive in today's rapidly changing world (The Education Commission, 2017). Zambia is one of the countries that continue to face challenges regarding the quality of its labor force as the majority of those seeking employment are not properly skilled in the specific jobs they want (Educational and Skills Sector Plan (ESSP, 2017-2021). The Zambian Education Curriculum Framework (2013) includes key competencies (21st Century Skills) to be acquired by the learners such as critical thinking, creative thinking, problem-solving, effective communication, relationships with others, participation, teamwork, and innovation. An emphasis on what learners can do with knowledge, rather than what units of knowledge they have, is the essence of 21st Century Skills. The framework does not specify particular subjects in which these competencies should be offered implying that the competencies are expected to be included in each and every subject offered in Zambian schools (Partnership for 21st Century Skills, 2007). However, the wide range of skills required for quality learner learning, and consequently quality teaching, call for essential competencies and skills beyond literacy and numeracy, otherwise known as 21st Century Skills. The term "21st Century Skills" includes the following skill set; creativity and innovation, critical thinking; problem solving; decision making, learning to learn; metacognition, communication, collaboration (teamwork), information literacy, ICT literacy, citizenship (local and global), life and career skills, and personal and social responsibility (including cultural awareness and competence) (Partnership for 21st Century Skills, 2008).

This study is focused on mathematics teachers as mathematics is considered one of the most important subjects in school education in Zambia and is set by the school curriculum as one of the five compulsory subjects. Mathematics is among the core subjects of 21st century learner outcomes. Therefore, learning mathematics encourages the attitudes, habits of thought, and patterns of thinking strategies which enable all to comprehend and respond to new situations which they have not met before (Afzal et al., 2004). Therefore, teaching and learning of mathematics can be used to advance 21st Century Skills (Partnership for 21st Century Skills, 2008). The way teachers implement the teaching process affects the outcomes of 21st century learning (Langworthy, 2013 ; Rusdin, 2018).

Building appropriate skills in Zambia will to a large extent depend on the quality of primary and secondary education, making this level of education an important area of interest (Education Skills Sector Plan (ESSP), 2017-2021). Critical thinking empowers individual citizens to assess the credibility, accuracy and value of information, analyze and evaluate information, make reasoned decisions and take purposeful action. Creativity entails the ability to recognize and act on opportunities and the willingness to embrace risk and responsibility. Communicating and collaborating with teams of people across cultural, geographic and language boundaries is a necessity in diverse and multinational workplaces and communities. For effective work in the industry and positive contribution, the learners need to know and understand the requirements from them by the industry. Rios et al., (2020) also contends that oral and written communication, collaboration, and problem-solving skills are in high demand by employers (Rios et al., 2020). Therefore, ensuring that education at all levels remains a sound investment for governments and individuals in the 2st century society is crucial for human capital development which in turn enhances economic growth. In this view, pedagogy, curriculum, school rules and climate, assessments, and bench marking skill acquisition are all key factors in the way 21st Century Skills are monitored and developed (Partnership for 21st Century Skills, 2008).

The Education 2030-SDG4 Agenda calls on Member States to strengthen the quality of education by equipping all learners in an equitable way with relevant skills that help them thrive in today's and tomorrow's world. Within the SDG4, the target 4.7, explicitly aims at ensuring that "all learners acquire knowledge and skills needed to promote sustainable development (Care, 2020). Zambia as one of the member states aspires to address the need to attain the desired human capital development by building inclusive and appropriate skills that respond to the demands of the labor market in order to achieve national development in alignment with Vision 2030 (Zambia Seventh National Development Plan, 2017-2021).

Therefore, the focus of this research is on the 21st-century learning and innovation skills which include; creativity, critical thinking, communication and collaboration skills which are essential for preparing learners for the future; they are teachable and learnable in the formal education sector and prepare learners for lifelong learning. Focusing on the aforementioned skills out of all the other 21st Century Skills is justified because they are foundational, interconnected, relevant across disciplines, essential for future careers, crucial for lifelong learning, and align with educational goals as well as employer demands. They serve as a practical framework for developing a wide range of skills essential for success in the 21st century. It is in this regard that modern learning cannot survive without 21st Century Skills. Therefore, teaching and learning of mathematics can be used to advance 21st Century Skills (Partnership for 21st Century Skills, 2008).

This study is focused on the teaching and learning of the mathematics topic mensuration in Zambian secondary schools, grade eleven to be specific. Mensuration in mathematics deals with the geometric qualities of 2D and 3D shapes such as the area, volume, and perimeter. In other words, the study of measurements of these shapes is known as mensuration. Mensuration formulas involve both 3D and 2D shapes. The most commonly used formula is the surface area and volume of these shapes. It also includes computation using mathematical formulas and algebraic equations. It is a division of mathematics that involves the study of geometric figure calculation and its parameters such as area, sectors, length, volume and surface area (Lewis, 1975).

We live in a three-dimensional world thus the concept of measurement plays an important role in primary as well as secondary school mathematics. In addition, measurement has a direct connection to our everyday lives because learning to measure objects includes both 3D shapes and 2D shapes. Mensuration highlights the need for standard units of measurement. To measure parameters like length, weight, and capacity we have units like kilometer, meter, kilogram, gram, liter, milliliter, etc. Mensuration is an important topic with high applicability in real-life scenarios. Some of the scenarios include finding the area, total surface area and volume of 2D shapes and 3D solids, for instance measurement of agricultural fields, floor areas required for purchase or selling transactions; measurement of volumes required for packaging milk, liquids, solid edible food items; measurements of surface areas required for estimation of painting houses, buildings; volumes and heights which are useful in knowing water levels and amounts in rivers or lakes as well as optimum cost packaging sachets for milk etcetera. like tetra packing (Afzal et al., 2004).

Therefore, mensuration has several day-to-day implications and hence, it is necessary to learn by all the learners. Learning mensuration provides learners with many foundational skills and helps them to build their logical thinking skills, deductive reasoning, analytical reasoning, and problem-solving skills which are pertinent for learner acquisition of the 4Cs. It is also an important part of the school mathematics curriculum as it symbolizes a move from concrete to abstract thinking (Hunt et al., 2011). Thus, contributing to their holistic development in readiness for the 21st century society. Mensuration as a concept allows the learners to connect mapping objects in the classroom to the real-world contexts in respect to their direction and place developing their practical thinking. It also increases learners' awareness and understanding of spatial relationships that are important in the role of problem-solving and higher-order thinking skills (HOTS) which mensuration allows learners to be equipped with. It finds huge applications in the real world as it helps in decision making on which materials to use, which design to make, and even plays a vital role in the construction process itself. It minimizes the wastage of material; this method is beneficial if a certain amount of products are to be made in order to increase it's efficiency with reducing wastage. Thus, it is useful for the learners and consequently if taught well facilitates learner acquisition of 4Cs.

1.3 Statement of the Problem

Despite global, regional, and national aspirations towards a 21st Century Skills learning agenda, implementation of the said skills does not dominate classroom teachers' practices (Care et al, 2018). Moreover, a study involving 152 countries (including Zambia) found that specific skills embedded within their curricular documents did not show evidence of progression in classrooms (Care et al., 2018). The disconnection between the vision of policy makers in education and the reality in mathematics classrooms is becoming more evident with the gap between the skills required by the society and the economy for young people to integrate and perform competently in the labor force (Care, 2020). According to Care (2020), "the twenty-first century skills; communication, collaboration, creativity and critical thinking(4Cs) are now firmly ensconced as new learning goals in education systems worldwide, but their implementation in teaching and assessment practices is lagging behind" (p. 2). Further on, Kim & Care (2017) stated that in comparison to the educational assessment of content-based knowledge, assessment of 21st Century Skills is in its infancy. "To date, there has been little attention paid to construct validation of assessments in the classroom, or to predictive validity based on evidence of the generalizability of skills-based learning" (p. 23). Similarly, PISA also stated that school systems are not outstandingly

successful in preparing learners for the kinds of abilities and skills that build the foundation for lifelong learning. PISA attainments shed light on this aspect as they are based on a dynamic model in which new knowledge and skills that are necessary for successful adaptation to a changing world are continuously acquired throughout life (OECD, 2008). This seems to suggest the existence of a dire need for teaching practices that integrate such skills to foster learners' acquisition of the same skills. The question that arises is why this scenario should persist when the agenda to promote learners' acquisition of the skills is prominent. Care (2018) contends that "challenges specific to assessment of 21st Century Skills may be one reason why education systems are having difficulties in translating policies into actual practices in schools and classrooms" (p. 2). This in turn affects economies of countries as a highly skilled work force can raise economic growth by about two-thirds of a percentage point every year (The Growth Report, 2008). Concurrently, Partnership for 21st Century Skills (2008) revealed that Programme for International Learner Assessment (PISA) results are economically significant alluding to the fact that countries that do well on PISA, which measures 21st Century Skills such as critical thinking and problem solving, have demonstrated higher increases in Gross Domestic Product (GDP) growth than countries that do not, according to a series of studies by Stanford University researchers (Partnership for 21st Century Skills, 2008).

In view of the aforementioned, it can be argued that the 4Cs are pertinent to a country's economic growth as these skills are essential in the work industry. If issues pertaining to integration of the 4Cs in the teaching and learning of secondary school mathematics are not addressed, production of secondary school graduates, who are not creative, innovative, critical thinkers and problems solvers may persist hence compromising the sole purpose of education. Consequently, countries with such are likely to experience low attainment of the desired human capital development and inadequate skills as well as poor technology innovation. This could contribute to low labor productivity which is a key binding constraint to economic growth (Education Skills Sector Plan (ESSP), 2017-2021). Internationally, several studies have been carried out in relation to integration of 21st Century Skills in teaching and learning of mathematics and other subject areas (National Mathematics Advisory Panel, 2008). As earlier intimated, findings from such studies have shown that the 21st century learning goals have been included in education systems worldwide, but their implementation in teaching and assessment practices is lagging behind. To the contrary, the Zambian context lacks studies of that kind which creates a basis for the current study. In this regard, the current study sought to find out the classroom practices of mathematics teachers in the context

of 21st Century Skills. The idea was to inform the Zambian and international mathematics education community as a way of mitigating the earlier highlighted discrepancies.

1.4 Purpose of the Study

The main aim of this study was to investigate how classroom practices in the teaching and learning of mathematics are aligned with facilitation of learners' acquisition of 21st century learning and innovation skills; communication, collaboration, creativity and critical thinking in a typical Zambian secondary school classroom. This study attempted to seek evidence of 4Cs reflected at classroom-level in terms of, how formative assessment tools and learning domains are embedded in the mathematics classroom, and whether there is potential to adapt existing tools to better integrate these skills.

1.5 Specific Study Objectives

General objective: To seek evidence of 21st Century Skills in the mathematics classroom in a selected secondary school in Lusaka district.

This study was guided by the following three objectives:

1. To determine what mathematics teachers know about 21st Century Skills.
2. To determine how mathematics teacher's classroom practices align with facilitation of learners' acquisition of 21st Century Skills.
3. To comprehend ways in which classroom-based assessments as administered by mathematics teachers are aligned with 21st Century Skills.
4. To establish the challenges from the perspective of mathematics teachers in the context of teaching for learners' acquisition of 21st Century Skills.

1.6 Research Questions

To achieve the stated objectives, four main research questions were designed and these were:

1. What constitutes mathematics teachers' understanding of 21st Century Skills towards teaching and learning at secondary school level?
2. How aligned are mathematics teachers' classroom practices to fostering of learners' acquisition of 21st Century Skills?

3. How are classroom-based assessments as administered by mathematics teachers aligned with 21st Century Skills?
4. What challenges do mathematics teachers say they face in line with teaching for learners' acquisition of 21st Century Skills?

1.7 Significance of the Study

The findings of this study might greatly contribute towards knowledge acquisition by learners which might justify stakeholders' expectations of mathematics teachers' integration of 21st Century Skills in the teaching and learning of mathematics at secondary school level. It may also enlighten policy makers in Zambia on the relationship between policy intentions and classroom realities. The findings of this study may have a practical implication for the policy of school systems in preparing learners for the kinds of skills and abilities that build the foundation for lifelong learning. Further, they may be used as a resource document for Zambian policy makers, teachers, teacher institutions, researchers and the general public.

1.8 Theoretical Framework

This study was based on the ideas and concepts of the curriculum integration theory by curriculum theorist, Beane (1997). Beane (1997) anchored his concept of curriculum integration on his principles for middle schools, specifically the curriculum should be general, and helpful for young adolescents exploring self and social meanings. Curriculum integration guidelines can support teachers as they frame learning in terms of important issues that learners can explore in different ways and connect to themselves and their world (Ali & Maat, 2019). The 21st Century Skills are to be developed with the perspectives of existing school subjects. Therefore, 21st Century Skills learning and innovation skills are not the contents kept in the curriculum but can be inbuilt in each of the subjects of the existing curriculum and this is known as a nested integrated curriculum which mainly targets; social, thinking and content skills within a subject area. This is not a matter of teaching either academic or 21st century knowledge and skills. It's about fusing the two, so that learners meet the demands of a global economy, as well as engage in good citizenship and participate fully in a vibrant and civil society. It gives attention to several areas at once and leads to enriched and enhanced learning which keeps the learners motivated and engaged (Fogarty, 1991).

The findings in Lipson (1993) support the positive effects of curriculum integration in that it helps learners to be able to apply the skills they learn in school to the real world (Lipson, 1993). In this regard, teaching secondary school in the 21st century mathematics classroom requires teachers' knowledge of what 21st century learning and innovation skills entail, teachers' capability to integrate them in teaching, resources required for successful teaching and learning should be made available and school management should support the innovation for successful implementation. Consistently, the partnership of 21st Century Skills (CISCO) developed a comprehensive framework that identifies specific skills, content knowledge, expertise and literacy's that must be established if learning has to be transformed. The partnership identified five critical support systems to ensure learners mastery of 21st Century Skills and these include: 21st century standards, 21st century curriculum and instruction, assessment of 21st Century Skills, 21st century professional development and 21st century learning environments. The Partnership for 21st Century Skills (P21) believes that one of the most important ways to enable learners to achieve this mastery is to fuse mathematical content and mathematical practices with the 21st Century Skills outlined in P21's Framework for 21st Century Learning. Fusing a core subject like mathematics with 21st Century Skills makes teaching and learning more engaging, more relevant and more rigorous, ensuring that a greater number of learners have an advanced level of understanding and ability in mathematics (Partnership for 21st Century Skills, 2008).

This theory is applicable to guide this study because the factors that Lipson advocates are in relation to five critical support systems identified by P21 on which this study is focused. The elements described below are the aforementioned critical support systems necessary to ensure learner mastery of 21st Century Skills. The researcher focused on three of the five elements of the critical support systems identified by P21which include assessment of 21st Century Skills, 21st century curriculum and instruction as well as 21st century learning environments (Partnership for 21st Century Skills, 2008). Focusing on these three elements provides a holistic perspective on how educational systems can better support the development of 21st Century Skills among learners. This allows for a focused and in-depth analysis while still addressing key aspects of 21st century education in the classroom. Assessment of 21st Century Skills ensures a balance of assessments, including high-quality standardized testing along with effective formative and summative classroom assessments. It puts emphasis on the use of feedback on learner performance that is embedded into everyday learning and it requires a balance of technology-enhanced, formative and summative assessments that measure learner mastery of 21st Century Skills (Sulaiman & Ismail, 2020). In addition, the 21st Century Curriculum and Instruction consists of teacher's 21st Century

Skills discretely in the context of core subjects and 21st century interdisciplinary themes. It focuses on providing opportunities for applying 21st Century Skills across content areas and for a competency-based approach to learning. Further on, 21st Century Learning Environments aim at creating learning practices, human support and physical environments that will support the teaching and learning of 21st century skill outcomes (Partnership for 21st Century Skills, 2008).

1.9 Conceptual Framework

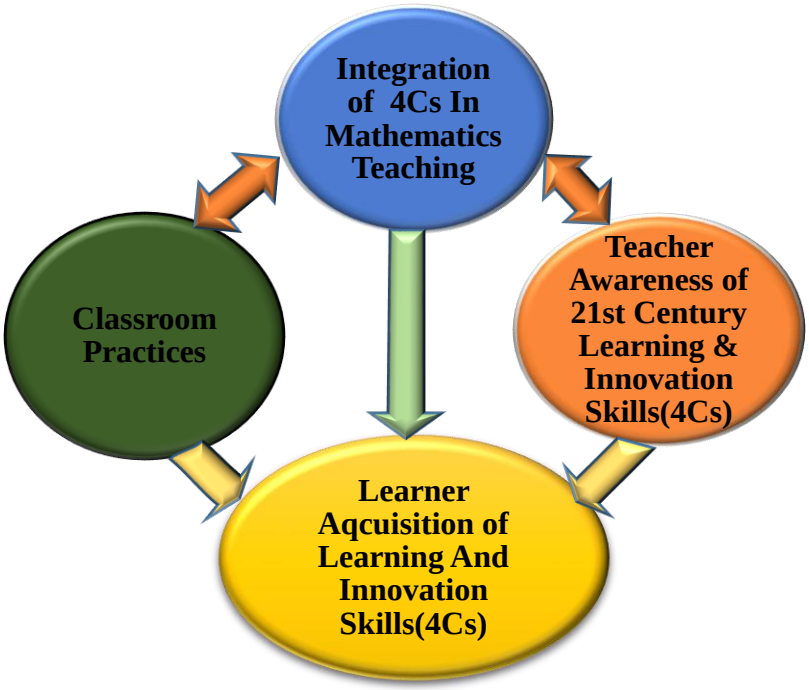

Figure 1.9: Curriculum Integration Conceptual Framework (Developed by the researcher)

The above conceptual framework in *Figure 1.9*, as depicted above, encompasses interconnected concepts that interlink the study's objectives, research questions, theory, and literature review. The focal points of "Teacher Awareness of 21st Century Learning Skills (4Cs)," "Classroom Practices," and "Learner Acquisition of Learning and Innovation Skills (4Cs)" are integral components in the endeavour to integrate 4Cs into Mathematics Teaching. These notions are aligned with the five advocated concepts of the P21 framework: 21st century standards, assessments, curriculum, instruction, and learning environments. This alignment is crucial for effectively implementing the core values of the Zambian curriculum within the educational system, particularly in the realm of mathematics education. These intertwined concepts have

a symbiotic relationship that contributes to the introduction of 21st century learning into the mathematics classroom. The awareness of teachers regarding 21st Century Skills is a pivotal factor in determining how these skills, tools, and teaching strategies can be seamlessly integrated into their teaching practices. This awareness also aids in discerning which activities can be de-prioritized and in adapting formative assessment methods to capture learners' demonstrations of these skills.

A proficient 21st century educator possesses the capability to cater to the diverse characteristics and skills of every learner within the classroom. Such an educator engages in managing the learning environment, wherein both the teacher and learners play a role in shaping the classroom dynamics. This encompasses aspects like forming classroom groups, devising tasks and activities, and utilizing instructional resources such as textbooks. A key aspect of achieving cohesion in 21st century education lies in the close interconnection between curriculum, assessment strategies, and teaching methodologies. This synergy ensures that the intended learner learning outcomes specified in the curriculum are evaluated through tasks that gauge their achievement. These assessments are influenced by the teaching approaches and activities employed in the classroom, which, in turn, support the learning objectives and prepare learners for assessments. This interrelated approach fosters effective education, as highlighted in the work of (Sulaiman and Ismail, 2020).

1.10 Scope of the Study

The study was conducted at a selected STEM public secondary school in Lusaka district involving two regular Grade 11 teachers and their respective classes of learners of mathematics. This was because grade eleven learners had covered a number of mathematics topics and would soon write their final exams and join the larger society. The Grade 11 learners instead of Grade 12 learners were selected to participate in this study because at the time the current study was carried out (term 3 of the school calendar), the latter were preparing for their final examinations. Hence involving the Grade 12 learners in this study would have interrupted their examination preparations.

The context of the selected school in the current study, a public secondary institution with a technical school background and being a part of the initial group of 52 pilot secondary schools for the 2020 STEM curriculum implementation aligned with Zambia's Education Curriculum Framework of 2013. The aforementioned background provided the basis for the importance of examining mathematics teachers' classroom practices in the selected secondary school as the integration of communication, collaboration,

creativity and critical thinking (4Cs) into the mathematics classroom reflect efforts to modernize educational practices and equip learners with relevant skills for the contemporary world (MoGE, 2020). The 4Cs are enshrined as core values in the 2013 Zambian Curriculum Framework and hence they are pertinent in the implementation of the STEM curriculum.

However, the decision by Dr. Jobbicks Kalumba, then Permanent Secretary Technical Services at the Ministry of General Education, to halt STEM education implementation on May 7, 2021 (which happened before the undertaking of the current study) in response to stakeholder concerns, highlighted the challenges and complexities involved in effectively delivering STEM education (Magasu et al., 2021). This decision signalled the need for careful consideration of various factors, including curriculum design, resource allocation, and stakeholder engagement, to ensure the successful implementation of STEM education in Zambian schools. It was on this basis that the current study sought to examine mathematics teacher's classroom practices in the context of 21st Century Skills at the selected secondary school.

1.11 Limitations of the Study

The study was only conducted in Lusaka district. Non-probability sampling was used in this study and thus not every member of the population of mathematics teachers and learners had an equal chance of being selected from the school. Therefore, the findings of this study may not be generalized. To address this limitation, the researcher appreciated the rich information provided from the purposively selected participants as the information helped to make a theoretical contribution in the teaching and learning of mathematics. Secondly, attaining access to participants was challenging. For example, some participants were reluctant at the thought of being 'scrutinized' by researchers. To address this limitation, the researcher assured the participants that the information provided was for research purposes only and that their identities would be kept anonymous.

1.12 Operational definitions of key terms

21st century assessment: classroom-based (formative) assessment in alignment with the 21st century learning and innovation skills; communication, collaboration, creativity and critical thinking. It encompasses

	multiple aspects of learning assessment, including the skills assessed and the methods used.
21st Century Learning:	is characterized by higher order thinking, meaningful inquiry-based learning, collaborative teamwork, effective communication, creativity and innovation, and digital literacy.
21st Century Skills:	refers to learning and innovation skills which include; communication, collaboration creativity and critical thinking.
Classroom Practices:	a set of strategies and instructional methods that characterize the interaction between teachers and learners in the classroom, which are meant to promote learning, as well as develop and manage learner's behavior. In my study, classroom practices include: teaching strategies and learning activities (this definition excludes formative assessment as it is dealt with independently).
Curriculum implementation:	integration of 21st century learning and innovation skills; communication, collaboration, creativity and critical thinking in the teaching and learning of Secondary School mathematics.
Curriculum integration:	in its simplest conception, it is about making connections across disciplines, to real life connections skill-based or knowledge-based.
Performance Assessment:	refers to tests designed to measure the knowledge, skills, and abilities attained by an individual in a field, in a subject area, or in a content domain in which the test taker has received training or instruction.
Teacher Awareness:	in this research Teacher Awareness refers to teachers' knowledge of 21st century learning and innovation skills; communication, collaboration, creativity and critical thinking

1.13 Summary of Chapter One

This chapter gave a clear insight into the topic under investigation: Mathematics Teachers' Classroom Practices in the Context of 21st Century Skills. It has demonstrated that the learning and innovation skills (4Cs) are essential in ensuring that learners meet the demands of a 21st century society. It has been stated that these skills make learners job ready and are mainly required in the work industry. Despite their inclusion as core values in the 2013 Zambian curriculum, the gap in terms of integration of the 4Cs in the teaching and learning of mathematics has continued to be illuminated through assessment as well as traditional classroom practices. The study was informed by the curriculum integration and P21's Framework for 21st Century learning theories. These theories emphasize the essentiality of fusing already existing subject content in the curriculum with 21st Century Skills and knowledge so that learners meet the demands of the global economy. This chapter highlights Teacher Awareness of 21st century learning skills (4cs), classroom practices and learner acquisition of learning and innovation skills (4cs) as the main concepts of integration of 4cs in mathematics teaching. The conceptual framework which is in diagrammatic form contains key concepts for this investigation. In a nutshell, chapter one dealt with background of the study, problem statement, purpose of the study, research objectives and questions, significance of the study, theoretical and conceptual frameworks, scope of the study and operational definitions of terms. The next chapter reviews a number of literatures on implementation of 21st Century Skills in the classroom.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

This chapter reviews relevant literature which serves as a lens for this study which focuses on variables related to mathematics teachers' classroom practices in the context of 21st Century Skills and their contribution to learner acquisition of the said skills. According to Neuman (1997), a literature review is based on the assumption that knowledge accumulates and that we learn from, and build on, what others have done. The goals of a literature review are to demonstrate the researcher's familiarity with a body of knowledge that already exists about the subjects of research and establish the credibility of such knowledge, showing the path of prior research and how the current project is linked to already completed research. It integrates and summarizes what is known in and about the selected area of research while considerably learning from others and stimulating new ideas. Literature review provides the analysis of previous research to a topic. It is a process of reading, analyzing and summarizing scholarly material about specific topic with the view to inform the current study and identify knowledge gaps. This study, in line with Neuman's (1997) aforementioned goals, used existing literature to investigate mathematics teachers' classroom practices in the context of 21st Century Skills. For this purpose, an extensive and relevant literature review was conducted in an attempt to provide a theoretical foundation for the research project.

The literature review provided a basis for the research question(s), and enabled the researcher to verify their findings and to compare these with the work of other scholars in the field of education. The following sections are addressed in this chapter: Overall outline of integration of 4CS in mathematics teaching; Studies on Teacher Awareness of 21st Century Learning Skills (4CS); Studies on Classroom Practices; and Broad Learning Outcomes of 21st Century Skills. In this section, the integration of 4Cs (Communication, Collaboration, Critical Thinking, and Creativity) in mathematics teaching emphasizes developing essential learning and innovation skills in learners is outlined. This involves a balanced approach of direct instruction and project-oriented methods to foster deeper understanding and acquisition of 4Cs. After reviewing the sources, the researcher looked at why 21st century education was introduced and how it is being applied in Zambia. This could have an impact on teachers' understanding of 21st Century Skills and how they can be implemented in the mathematics classroom. Related studies on 21st

Century Skills further revealed the core principles for integration of 21st Century Skills in the teaching and learning process, the challenges experienced in the classroom and how they can better be addressed in order to ensure progress towards attaining a successful 21st century education.

2.2 Overall outline of Integration of 4CS in Mathematics Teaching

Integration of 4Cs in mathematics teaching describes the learning and innovation skills as the skills learners should develop and how they can be integrated and developed in any mathematics lesson. It entails teachers balancing direct instruction with teaching methods that are project-oriented and further illustrates how a deeper understanding of subject matter can actually enhance learner acquisition of the 4Cs. The notion that skills and content are best learned together is also one of the major findings of a recent report on mathematics education released by the U.S. Department of Education. The report asserts that the best learning happens when learners learn the basic rules and procedures of arithmetic at the same time that they learn how to think and solve problems. In this view, the best educators know that learners cannot develop and use skills without a core body of knowledge (National Mathematics Advisory Panel, 2008).

The introduction of 21st Century Skills in the Zambian education system is likely a response to the evolving demands of the modern world and the need to prepare learners for the challenges and opportunities of the 21st century as elucidated in ESSP 2017-2021 and the 2013 Curriculum Framework. These skills are considered crucial for individuals to thrive in an increasingly globalized, technology-driven, and interconnected world. Some of the key reasons for introducing 21st Century Skills in the Zambian education system include:

1. **Globalization and technological advancements**: The rapid advancements in technology and globalization have transformed the way people live and work. To participate effectively in the global economy and workforce, learners need to possess skills that go beyond traditional academic knowledge.

2. **Changing workplace requirements**: The job market is evolving, with an increasing emphasis on skills such as critical thinking, problem-solving, creativity, communication, collaboration, and adaptability. These skills are sought after by employers as they enable individuals to be more innovative, flexible, and resilient.

3. **Preparation for an uncertain future**: The future is characterized by uncertainties and complex challenges. Equipping learners with 21st Century Skills enables them to navigate uncertain situations, continuously learn, and be better prepared for various scenarios.

4. **Problem-centered learning**: 21st Century Skills are often integrated into problem-centered and inquiry-based learning approaches, which foster active engagement and deeper understanding of concepts.

5. **Holistic development**: Beyond academic achievement, the education system acknowledges the importance of holistic development, including social-emotional skills, digital literacy, and cultural awareness.

6. **Enhancing citizenship and civic engagement**: 21st Century Skills can empower learners to become informed, responsible citizens who actively engage in their communities and contribute positively to society.

7. **Addressing global challenges**: Many of the challenges facing the world today, such as climate change, poverty, and inequality, require innovative solutions. 21st Century Skills promote creative and collaborative problem-solving to address these issues.

8. **Alignment with educational trends**: Internationally, there has been a growing recognition of the importance of 21st Century Skills in education. Zambia, like many other countries, is aligning its education system with these global trends to ensure its learners remain competitive on a global scale.

By integrating 21st Century Skills into the education system, Zambia aims to produce well-rounded, adaptable, and forward-thinking individuals who can contribute positively to the nation's development and navigate the challenges and opportunities of the 21st century effectively. In order to prepare for success in life, education must focus on developing the critical thinking skills of learners. With these skills learners will be prepared to cooperate successfully, think critically and analytically, communicate effectively and solve problems efficiently in the workplace. This signifies that communication, collaboration, creativity and critical thinking work hand in hand hence the focus of this study being the 4Cs. Such activities require learners to be involved in active learning, be engaged in high-level problem-solving skills and be able to participate in teamwork activities with the intention that learners will develop strong leadership,

communication, and teamwork skills, cross-cultural and cross-national awareness, and most essentially, confidence in their ability to contribute to the science and engineering community" (Kalonji, 2005).

2.3 Studies on Teacher Awareness of 21st Century Learning Skills (4CS)

In order for graduates to be job-ready, secondary education needs to inculcate 21st Century Skills and vocational skills demanded by employers. The reforms required to achieve these ends include instructional techniques need to be more learner-centric and the curriculum and assessment must emphasize 21st Century Skills development, such as learning to learn, team-work, communication, problem-solving, and the encouragement of commitment (Blom et al., 2017). Teachers are responsible for the successful implementation of 21st century learning. Teachers' perception, knowledge, skills and practice influence the effectiveness of their teaching (Sulaiman & Ismail, 2020).

One salient aspect of encouraging the incorporation of 4Cs in instruction and learning is heightening Teacher and learner awareness of these skills. Teachers need to be mindful and intentional of ways to elicit the 4Cs which are communication, collaboration, creativity and critical thinking by selecting rich problems, providing learning environments, and creating learning structures that amplify these skills. The teacher selects a rich problem as a mathematics scenario that can be solved in multiple ways with multiple mathematical connections that can link the application of skills to real life. Spending time on a rich problem with a meaningful context may benefit learners as they transfer the mathematics skills and concepts to a real-life application. A teacher must also work with learners in creating a learning environment that promotes acquisition of 21st Century Skills by ensuring a classroom community that encourages respecting other learners' ideas in order for mathematical debate to be productive. However, the lack of Teacher Awareness of the 4Cs inhibits the teacher's timely support and mediation as collaboration requires a lot more effort and becomes time consuming, leading to failure in task completion (Rummel and Spada, 2005).

It is significant to note that, only when instructors understand the foundations of critical thinking can they effectively teach for it. "The simple truth is that teachers are able to foster critical thinking only to the extent that they themselves think critically" (Elder and Paul, 2010, p.38). The findings of a research carried out by Salehudin et al. (2015) proved that teaching strategy and approach play important part in drawing learners' interest towards a subject in this case mathematics and substantially changes their perception about the subject regarding to the difficulties. In confirmation, Care et al., (2018 p16) stipulated that: "the

lack of knowledge about 21CS domains is our first challenge to teaching and assessment of 21CS". This has serious implications for how curriculum, pedagogy, and assessment play out in the classroom and simply implies that the teaching and learning process should be deliberate in order to ensure that learners acquire the intended learning and innovation skills (4Cs). Therefore, the quality of the education system is inevitably dependent on the quality of the teachers who manage it.

In a study conducted by Rusdin (2018) on Teachers' Readiness in Implementing 21st Century Learning, the findings of the study implied that teachers are ready to implement 21st century learning but still need improvement to optimize the outcomes. The research was quantitative and involved a survey design which was conducted by using a questionnaire as a research instrument. The findings show that teachers' readiness in implementing 21st century learning is high, there is significant correlation between academic level and the level of understanding 21st century learning skills (Rusdin, 2018). Correspondingly, Fernández-Arias et al. (2021) stipulated that when teachers have a high self-conception of 21st Century Skills, they incorporate them in the teaching and learning process. However, if teachers lack conceptual knowledge about such skills, it will lead to the inability to integrate them during the teaching and learning process hence the inclusion of establishing the level of Teacher Awareness as one of the objectives of the current study. Despite the impressive information given by the aforementioned studies about 21st Century Skills, there was still scanty information on teachers' levels of awareness of 21st Century Skills in Lusaka district Zambia hence this current study.

In an attempt to make education more relevant to society, a study done by Sulaiman and Ismail (2020) on teacher competence and 21st Century Skills in transformation schools shows that there is a robust and positive relationship between professional competence and 21st Century Skills among teachers. The findings also predict that personal characteristics, pedagogy, professional, information and communication technology (ICT), as well as school management and development, are significant contributors to 21st Century Skills. Equally, the study revealed that the dimensions of teacher competence have the potential to help further develop the potential of teachers in line with 21st century learning (PAK-21) concepts. The findings by the previous study depicts an idea that in order for teachers to be able to transfer 21st Century Skills to the learners, they should be embedded with innovative pedagogy. In spite of the study by Sulaiman and Ismail, the levels of competence among teachers of Lusaka district to transfer 21st Century Skills to learners were not yet known.

According to a study done by Charles-Ogun and George on Investigating Difficult Concepts in Senior Secondary School Mathematics Curriculum as Perceived by learners employed the survey research design aimed at investigating difficult concepts in senior secondary school mathematics curriculum as perceived by learners in River's state. The study was guided by two research questions and the sample for the study was 250 SS3 learners. The instrument used for the collection of data was a 31-item questionnaire tagged Difficult Concept Identification Questionnaire in Mathematics (DCIQM). The instrument was validated and the reliability established using the test-retest method. The data obtained were analyzed using mean with the criterion mean set at 2.5. The findings of the study revealed that learners identified some mathematics topics (longitude and latitude, bearing and mensuration) as difficult topics. Based on the findings of the study, it was recommended amongst others that workshops should be organized to train mathematics teachers on the effective and efficient strategies that should be adopted for the teaching of the identified difficult mathematics concepts. Despite this study, there was limited information known about Zambia, Lusaka District in particular where the teaching of Mensuration is concerned.

A study conducted by Busaka et al., (2021) indicated the lack of adequate literature on the integration and assessment of soft skills which points to the fact that these skills may not be integrated in the teaching and learning of Mathematics, which may lead to producing school leavers who are not adequately prepared to contribute to the development of the country and fit well in society. The methodology used was document analysis. The study by Busaka et al relied-on document review to generate evidence on integration and assessment of soft skills hence not conclusive yet the latter study used interviews, classroom observation, performance assessment and document analysis to generate evidence on mathematics classroom practices in the context of 21st Century Skills hence the study was conclusive.

In a study conducted by Rusdin (2018) on teachers' readiness in implementing 21st century learning, the findings of the study implied that teachers are ready to implement 21st century learning but still need improvement to optimize the outcomes. The position by Rusdin is supported by Busaka et al. (2022) who conducted a study on Comparative review of literature on the integration of Soft Skills in Mathematics in which the findings showed that teachers' readiness in implementing 21st century learning is high, there is significant correlation between academic level and the level of understanding 21st century learning skills (Rusdin, 2018). Despite the robust information given by the previous studies on teachers' levels of awareness to fully implement 21st century learning, the relation of teacher's levels of awareness to classroom assessment and practices in Lusaka district remained scant.

Teacher awareness of 21st century learning skills encompasses a deep understanding of the skills deemed essential for success in today's rapidly evolving world, such as critical thinking, creativity, collaboration, communication, and technological proficiency. Teachers who are cognizant of these skills are more likely to integrate them into their instructional practices, creating dynamic and engaging learning environments for their students. Secondly, teacher awareness also involves an understanding of the importance of contextualizing learning experiences to real-world situations, thereby fostering relevance and applicability of knowledge. Teachers who are aware of the significance of connecting classroom learning with real-life contexts are better equipped to facilitate meaningful learning experiences for their students. Furthermore, teacher awareness extends to recognizing the need for continuous professional development to stay abreast of emerging educational trends and pedagogical approaches. Teachers who actively seek opportunities for professional growth are more likely to adapt their instructional practices to incorporate 21st century learning skills effectively.

2.4 Studies on Classroom Practices

The classroom is the primary environment where the aforementioned factors; Teacher Awareness of (4Cs), Classroom Practices, Learner Acquisition of Learning and Integration of 4Cs in Mathematics Teaching culminate to bring knowledge acquisition and skills development. The classroom is the space where learners observe the modeling of these skills by their teachers and can practice themselves. Classroom practices are a set of strategies and instructional methods that characterize the interaction between teachers and learners in the classroom, which are designed to promote learning, as well as develop and manage learner's behavior. They include; classroom management, pedagogy, learning activities, assessment as well as learners' engagement in learning and the use of instructional time. (Živković, 2016). One of the major issues that confronts education systems is a deficiency in the effective use of collected learner learning outcomes data. These include the inherent nature of transferable skills that can be demonstrated across different situations and in response to different contexts. Such skills require assessment approaches that are either sufficiently broad or sufficiently dynamic to capture this essential quality

A case study by Phiri & Jumbe (2020) on Promoting Learner Engagement in Soft Skills Practices with Science News Media in Physics Education at Chiwala Technical Secondary School in Zambia (2020) employed a study method and purposeful sampling technique with an embedded mixed-method data collection approach and analysis. The study utilized a learner open-ended questionnaire, a classroom

observation protocol, and assessment rubrics to collect data. The study established that learner engagement levels in soft skills practices were higher in classes where Science News Media (SNM) was integrated during the physics lessons than those in which it wasn't. It also established that SNM increased learners' awareness and interest to participate in soft skills practices during physics education. Finally, it established that learner engagement levels in soft skills practices were generally higher during debate and simulation than during lectures irrespective of the classes. This study focused on promotion of learner engagement in soft skills practices with SNM an aspect of technology literacy in Physics Education as opposed to the current study which focuses on the integration of the 4Cs in the teaching and learning of mathematics particularly on the topic mensuration. It also focuses on mathematics classroom practices that the teacher engages the learners to enable learners to acquire the 4Cs.

A pilot study conducted by Kim and Care (2020) on classroom-based assessments of 21st Century Skills was a pilot study. It's experience provided the national teams with a rich source of information to draw on for their continuing 21CS task development. The training, task administration, and scoring issues provided an equally valuable resource to inform the three education systems about the infrastructure required to effect change (Kim and Care, 2020). In Zambia, the target of the study was only on problem solving and collaboration. However, graduates in all three countries are almost exclusively examined through a national assessment of standard examinable knowledge. This form of assessment incentivizes teachers and learners to reduce classroom activities to rote-learning of standard examinable knowledge. Despite the former study including Zambia as part of the three target countries, the focus about Zambia was only on problem solving and collaboration as opposed to the latter study which focused on communication, collaboration, creativity and critical thinking.

In a study conducted by Unodiaku (2022) to determine the efficacy of the Constructivist's Teaching Method (CTM) on teaching proof of mensuration theorem: a panacea for senior secondary school learners' interest and achievement. The findings of the study clearly demonstrated that CTM is effective in enhancing learners' achievement and interest in mathematics learning, especially in proving mensuration theorems. These recorded significant mean differences in achievement and interest of the learners after they were exposed to the treatment showing that CTM is responsible for such enhanced increase in performance of the learners and their interest. However, the current study focuses on teaching activities and methods that foster learner acquisition of 4Cs in the teaching and learning of mensuration in a 21st century mathematics classroom inclusive of Constructivist's Teaching Method (CTM).

2.5 Studies on 21st Century Skills

Several studies have been carried out in relation to integration of 21st Century Skills in teaching and learning. The paragraphs below consist of a summary on existing literature on the 21st Century Skills in teaching and learning in schools, it highlights the authors, when and where the study was conducted, the methodology used, the findings and hence the knowledge gap.

According to Blom et al., (2017) in Botswana, Lesotho and Zambia, qualitative research was conducted which consisted of classroom observation using the instructional rounds approach. The findings were that pedagogy did not foster critical thinking. In addition, learners' teamwork, collaboration and active learning were generally absent and instruction in all classrooms was generally teacher centered. No evidence was found from the literature reviewed of the three countries on ascertaining the facts that soft skills integration and assessment are prioritized. Further on, mathematics teachers are equipped with skills to develop and assess soft skills. However, there was no indication of Mathematics teachers putting great effort in integrating soft skills as tools for developing learners understanding of the subject (Blom et al., 2017). This study focused on classroom observation as the only research and data collection instrument whereas the current study embraced more research instruments to generate rich information.

Teaching in the 21st century mathematics classroom is quite challenging where teachers should assess the learners with regards the 4Cs. Assessment of 21st century learning involves the evaluation of many skills and not just paper-pencil exam. Teachers need appropriate tools to assess the different skills and this could be done through performance assessments (Rusdin, 2018). Thus, 21st Century Skills implementation mechanisms need to be refined and applied by teachers to improve their competence. This situation has a massive impact on the teaching and learning process. Teachers' ability to use 21st Century Skills-based teaching has successfully increased learner motivation and engagement in developing these skills (Sulaiman and Ismail, 2020).

It is imperative to talk of 21st Century Skills without considering technology as the era we are in is technology driven. Technological Pedagogical Content Knowledge (TPCK), a part of the 21st Century Skills framework (P21) is a framework to comprehend and describe the kinds of knowledge needed by a teacher for effective integration of technology in all content areas. It argues that effective technology integration for teaching specific content or subject matter requires comprehending and negotiating the relationships among the three components which include: technology, pedagogy, and content.

Development of 21st Century Skills and competencies in teaching and learning remains a key strategic imperative (Partnership for 21st Century Skills, 2008).

Technology integration can be harnessed to foster effective teaching and learning. In view of the foregoing statement, Ramaila and Molwele (2022) examined the role of technology integration in the development of 21st Century Skills and competencies in Life Sciences teaching and learning. The empirical investigation adopted an explanatory sequential mixed method design and involved 15 purposively selected teachers from five South African suburban schools. The study found that technology integration was perceived to promote the acquisition of 21st Century Skills and competencies in Life Sciences teaching and learning. In particular, the teachers indicated that technology integration facilitates the development of skills such as communication, critical thinking, collaboration, problem solving and computational thinking. In an endeavor to investigate the possibilities of technology in transforming 21st century learning skills in schools, Mbako (2014) carried out a case study in Kenya. The study revealed that education system was not technology enabled. 66% of teachers were in opposition to contribute positively towards the development of 21st century learning skills. As to whether integration of technology enhances learners' development of 21st Century Skills, was too early in the education system to tell. Further curriculum has yet to incorporate IT assessment. This as well meant that curriculum as it is structured, is yet to adopt to address 21st Century Skills.

A study carried out by Bruce and Levin (1997), looked at ways in which the tools, techniques, and applications of technology can support integrated, inquiry-based learning to "engage children in exploring, thinking, reading, writing, researching, inventing, problem-solving, and experiencing the world." They found strong evidence that educational technology complements what a great teacher does naturally, extending their reach and broadening their learners' experience beyond the classroom. However, the three later consecutive studies did not bring out narratives on acquisition of 4Cs in the mathematics classroom.

In an effort to enhance integration of 4Cs in the teaching and learning of Mathematics, Chileshe et al., (2021) conducted a study in Kenya, Rwanda and Zambia on comparative review of literature on the integration of soft skills in Mathematics as reflected in the revised curriculum frameworks. The study revealed that there was lack of adequate literature on the integration and assessment of soft skills which points to the fact that these skills may not be integrated in the teaching and learning of Mathematics, which may lead to producing school leavers who are not adequately prepared to contribute to the development

of the country and fit well in society. However, this study lacked empirical evidence as it employed document analysis as the only tool for data collection and analysis.

In a study done by Care et al., (2018) communication, creativity, critical thinking, and problem solving were the four most frequently identified skills within national policy documents of the 152 countries which included Zambia. A study in 152 countries found that specific skills embedded within their curricular documents, but in 58 (38%) countries including Zambia did not show evidence of progressions of skills. Other skills identified include information technology, social, and entrepreneurship skills indicating that countries are explicitly identifying a wide range of skills beyond the academic (Care et al., 2018). Despite the narrative that there was no evidence on progression of skills in Zambia, there was need to get insights on why there is no evidence of such. Mathematics classroom instructional quality and its relationship to learning outcomes can serve as a critical lever for educational change. However, there is much still to be learned about what actually goes on inside classrooms, particularly Zambia.

A study carried out by Amirudin et al., (2015) investigated the effectiveness of an assessment task in enhancing the learners' understanding in mathematics through collaboration. The mathematics topic on Mensuration was selected for this project and the theme was the 'Go Green Project'. The task itself was designed to promote an active learning environment, and to foster creative learning in mathematics where the designed model was used to elicit the learners' understanding on finding the total surface area and the volume of solids. The results of the investigation revealed that effective level of collaboration had taken place among learners when using the designed assessment task. Findings suggest that when learners collaborated with one another, their communication skills had improved, fostered their critical thinking and encouraged them to share ideas. Thereby encouraging learner acquisition of 21st Century Skills. This study is in consonance with progressive education as described by Dewey which should include socially engaging learning experiences that are developmentally appropriate for young children (Dewey, 1938). Dewey thought that effective education came primarily through social interactions. However, the progression of the skill of collaboration on the topic mensuration was not known in Lusaka district.

Charles-ogan et al., (2014) investigated the possible effect of mathematics laboratory in enhancing learners' conception of mensuration in senior secondary school mathematics using demonstration and collaborative approaches in Rivers State. The findings established that learners who were taught using demonstration with Mathematics laboratory approach outperformed all their counterparts in terms of understanding of concepts of mensuration. The mathematics laboratory using demonstration and

collaborative approaches impacted significantly on learner comprehension of the concept of mensuration. It was recommended among others that mathematics teachers should incorporate mathematics laboratory using demonstration and collaborative approaches in the teaching of the concept of mensuration.

A study by Olatunde (2010) on the adequacy of resource materials (Mathematics laboratory) and learners mathematics achievement of senior secondary schools in south western, Nigeria revealed that out of 1750 senior secondary school learners and 123 mathematics teachers selected from 2 schools of the senatorial districts many (75%) had a good perception about the need for mathematics laboratory and learners exposed to the use of mathematical laboratory performed better (65%) than those who were not. Therefore, the use of Mathematics Laboratory as a Pedagogical approach in teaching and identifying learners' difficulties and misconceptions in mensuration had been effective. Comparably, Nwoke and Nnaji (2011) showed that the use of Mathematics Laboratory was more effective than the lecture method in teaching and learning mathematics with respect to learners' achievement. Sreedharal (2008) supported this advocacy by positing that the activities carried out in the mathematics laboratory make learners enjoy and rejoice with mathematics.

In reference to the above advocacy on effective pedagogical approaches in the 21st century mathematics classroom, my study targeted formative assessment of 4Cs in secondary schools in Lusaka district. Interventions that focus solely on curriculum and pedagogy, in the absence of an effective assessment mechanism, will not be sufficient to effectively develop 21st Century Skills. Assessment should seek to evaluate the extent to which learners are indeed acquiring all aspects of this rich and broad learning outcomes as shown in *Figure 2.5* below.

The 21st Century Skills Learner Outcomes and Support Systems

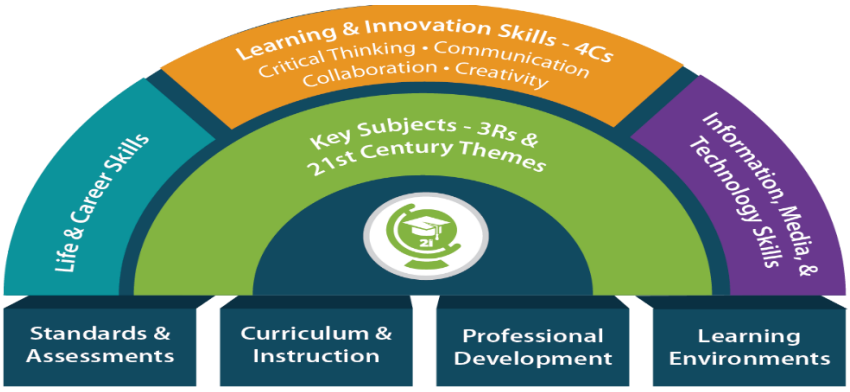

Figure 2.5: Implementation Framework Partnership for 21st Century Skills, 2008)

The above framework presents the implementation framework with a meta-curriculum wherein the curriculum, pedagogy, learning environment, and assessments are woven around Core Subjects and 21st Century themes. The elements described in this section as '21st Century Skills learner outcomes' (represented by the rainbow) are the knowledge skills and expertise learners should master to succeed in work and life in the 21st century. Learning and innovation skills are part of the P21 framework that separate learners who are prepared for increasingly complex life and work environments in today's world from those who are not. These skills include: creativity and innovation; critical thinking and problem Solving, communication as well as collaboration. Additionally, there are information, media and technology skills since we live in a technology and media-driven environment, characterized by access of abundant information, rapid changes in technology tools, and the ability to collaborate and make individual contributions on an unprecedented scale. Effective citizens and workers must be able to exhibit a range of functional and critical thinking skills, such as Information Literacy (IL), Media Literacy (ML) and ICT (Information, Communications, and Technology) Literacy. The P21 framework also includes life and career skills as learners in this era need to develop thinking skills, content knowledge, and social and emotional competencies to navigate complex life and work environments. P21's essential Life and Career Skills include: Flexibility and Adaptability; Initiative and Self-Direction; Social and Cross-Cultural Skills; Productivity and Accountability; Leadership as well as Responsibility. (Partnership for 21st Century Skills, 2008)

2.6 Broad Learning Outcomes of 21st Century Skills

Penetrating the world of a global market, employers look for graduate employees who are able to transfer their critical thinking abilities to the workplace (Tapper, 2004) and use a language in the facility of thinking and problem solving which constitute the 4Cs (Cummins, 1981). Most frameworks focus on various types of higher-order skills such as critical thinking, communication, collaboration, and creativity (also known commonly as the 4Cs). The 4Cs can be embedded in the instruction of a variety of academic disciplines, and faculty can design their course focus technique that is more thinking and social skills based (Halpern, 1998). Consequently, it is argued that educators should help learners to become successful for future work performance. These skills are divided into two categories; social skills (communication and collaboration) and cognitive (creativity and critical thinking).

Communication: learners should be able to communicate clearly through the use of effective oral, written and nonverbal communication in a variety of forms and diverse social, cultural, linguistic contexts.

Additionally, learners should also be able to listen effectively in order to infer meaning and use communication for a variety of purposes as well as functions. They should also be capable of using several forms of media and technologies and know their effectiveness. The discipline of mathematics equips learners with tools and habits of the mind to organize and interpret quantitative data. Informationally literate mathematics learners effectively use learning tools, including technology, and clearly communicate using mathematical language. It also involves learners to not only understand mathematical concepts but also effectively communicating mathematical reasoning and problem-solving strategies. This helps learners to become informationally literate mathematics learners who can clearly articulate their mathematical thinking and conclusions (Partnership for 21st Century Skills, 2008).

Effective communication skills are essential for mathematics teachers to facilitate meaningful learning experiences and support learners in developing a deep understanding of mathematical concepts within the context of 21st Century Skills. By prioritizing clear expression, encouraging participation, leveraging technology, and promoting mathematical literacy, teachers can enhance the teaching and learning of mathematics in secondary school classrooms. 21st century learning emphasizes the need for mathematics teachers to effectively communicate mathematical concepts to their learners using clear and precise language. This includes explaining mathematical principles, formulas, and problem-solving strategies in a way that learners can understand can understand. Therefore, it is the role of teachers to create opportunities for learners to engage in discussions, ask questions, and share their thoughts about mathematical concepts. This fosters a collaborative learning environment where learners can develop their communication skills while exploring mathematical ideas. Additionally, teachers in the 21st century mathematics classroom ought to leverage various forms of communication, including oral, written, and nonverbal methods, to cater to diverse learning styles and preferences among learners. This may involve using visual aids, technology tools, and real-world examples to enhance understanding and engagement (Schultz 2010).

Collaboration refers to working together in a team to achieve a common goal. Here, talent, expertise and smart work interact. The complexity of modern organizations necessitates the use of collaboration to solve problems (Hashim et al., 2019; Alaa, et al., 2019). Clients, customers and suppliers are scattered globally and contacts need to be made to complete projects, products, or programmes. Mathematics is a social discipline which involves the interchange of ideas. During the course of doing mathematics, learners present ideas, strategies, solutions, justifications, and proofs for others to evaluate. In turn, the

mathematics learner interprets and evaluates the ideas, strategies, solutions, justifications and proofs of others therefore exhibiting that collaboration can be developed by the learners in the classroom where individuals work together in pairs or groups.

Amirudin et al (2015) contends that in the 21st Century Learning Design, collaboration is made up of four main elements and these include; cooperation with team members, shared responsibility, making substantive decisions together and interdependent learners' work (Amirudin et al., 2015). Through the teaching and learning process of mathematics, learners should be able to collaborate with others; they should express the ability to work effectively and respectfully in diverse scenarios as well as be adaptable to accomplish a common goal. The 21st century learners ought to also assume shared responsibility for collaborative work, and value the individual contributions made by each team member (Winter, 2020). Collaboration is important for career and success in lifelong learning. The ability to work effectively with others is critically important. In order to foster critical thinking, problem solving and creativity, learners as well as teachers need to work in collaborative environments.

Collaboration is also crucial among teachers as it enables them to share lesson planning ideas and improve their teaching practices and professionalism. Subsequently, they will be able to improve their learners' performance and attitudes. Further on, collaboration can be enhanced using information and communication technology, this strategy is advantageous as the world becomes more interconnected. Mathematics teachers in the 21st century classroom ought to encourage learners to collaborate in pairs or groups to solve mathematical problems. This fosters an environment where learners can exchange ideas, strategies, and solutions, enhancing their understanding of mathematical concepts. Teachers should guide learners in developing essential collaboration skills, such as cooperation, shared responsibility, and making substantive decisions together. These skills prepare learners to work effectively in diverse scenarios and adapt to accomplish common goals, aligning with the principles of 21st century learning design.

Creativity and Innovation: learners should be able to think creatively, this can be observed through the use of various techniques for creating and evolving new ideas (such as brainstorming) as well as through the use of all available concepts to create or conceive as well as perceive useful ideas. Mathematics is a dynamic discipline, ever expanding as new ideas are contributed. In this view, through the learning of mathematics the learners should also be able to elaborate, refine, analyze and evaluate ideas to improve one's own creative efforts. Further, learners should exhibit the ability to work creatively with others and

develop, implement and communicate new ideas to others (Brandt, 2021). In a 21st century mathematics classroom, teachers foster an environment where learners can think creatively to solve mathematical problems. By incorporating techniques like brainstorming and encouraging the exploration of various concepts, teachers empower learners to approach problems from different angles and develop innovative solutions. Mathematics teachers encourage learners to work creatively with others, fostering collaboration and teamwork. By engaging in collaborative problem-solving activities, learners learn to develop, implement, and communicate new ideas to their peers, enhancing their ability to innovate collectively. Through the intentional teaching practices in the mathematics classroom, teachers help learners to understand the dynamic nature of mathematics and encourage them to embrace innovation and creativity as they explore mathematical concepts and theories.

Critical Thinking: Mathematics is a discipline grounded in critical thinking, it is considered to be one of the fundamental subjects to sharpen and augment critical thinking skills of learners. Doing mathematics entails recognizing problematic aspects of situations, devising and carrying out strategies, judge the reasonableness of solutions, and justifying methods, strategies, and solutions. Learners should be able to analyze how various parts of a system complement each other for a complete picture to be formed in the mind of the learner (ŽivkoviĿ, 2016). In order to solve a problem, learners need to initially identify the problem and then analyze it to examine whether or not it can be solved. After that, they need to look at various possibilities to solve it. Eventually, they need to select the most effective and efficient way of overcoming it. Therefore, mathematics provides the learners with the necessary grammar and structure that make it possible for them to describe patterns that exist in nature as well as society (Hashim et al., 2019).

In a 21st century classroom, mathematics teachers play a crucial role in guiding learners to effectively analyse mathematical problems. They facilitate activities that enable learners to recognize problematic aspects of situations and identify key components of problems. Through diverse approaches, teachers assist learners in devising and executing strategies to solve problems, emphasizing the importance of critical evaluation. Teachers also encourage learners to reflect on their problem-solving processes, ensuring that solutions are reasonable and justifiable.

Furthermore, mathematics teachers promote systems thinking, helping learners understand how various parts of mathematical systems complement each other. This approach enables learners to analyse relationships and patterns within mathematical concepts and apply them to real-world situations. By

fostering a comprehensive understanding of mathematical systems, teachers empower learners to tackle complex problems with confidence and competence, preparing them for success in the 21st century and beyond. Generally, critical thinking is integral to mathematics teachers' classroom practices in secondary schools within the context of 21st Century Skills. By fostering problem recognition, strategic problem-solving, evaluation of solutions, systems thinking, and descriptive and analytical skills, teachers equip learners with the essential tools for success in mathematics and beyond.

2.7 Research gap

In this literature review, many authors acknowledged the importance of 21st Century Skills. However, despite many scholarly work reviewed, studies do not bring out empirical argument about teachers' levels of awareness of 21st Century Skills in Lusaka district, how mathematics teacher's classroom practices align with facilitation of learners' acquisition of 21st Century Skills and ways in which formative assessments as administered by mathematics teachers are aligned with 21st Century Skills in Lusaka district. The literature reviewed is also scant in that it does not fully address new ways in which schools approach the teaching of 21st Century Skills in the mathematics classroom. It was for this reason that this study intended to establish and bring out both the theoretical and empirical arguments about the study themes under consideration.

2.8 Chapter summary

The chapter has discussed literature review on elements attributed to the teaching of 21st Century Skills in Mathematics. Scholars cited both theoretical and empirical have demonstrated knowledge and an understanding of the topic in context. It has been shown in the literature that the lack of information on how to transmit 21st Century Skills when teaching mathematics may affect the goal of producing scientific oriented learners who are expected to solve various problems faced in society. Thus, it has been demonstrated that teachers should endeavor to meet learner's levels of learning difficult by helping them to be creative, innovative and inculcate the learning hand innovation skills. The next chapter contains the methodology which was employed when conducting this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This section focuses on the methodological approaches that were used. It mainly focuses on the research paradigm, research design, study site, the target population as well as sample size. Further, the chapter explains the sampling techniques used, data collection methods, instruments for data collection and how data was analyzed. The degree of confidence placed in the findings is explained through four dimensions of trustworthiness. The chapter ends by highlighting ethics that were followed when conducting the study.

3.2 Research Paradigm

Research paradigms are preferred ways of understanding reality, building knowledge and gathering information about the world. In the context of this study, the researcher used qualitative approach underpinned by social constructivism. In alignment with Crotty (1998) who posits that social constructivism as the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. This paradigm, like the functionalist paradigm, belongs to the sociology of regulation and its purpose is to understand the world from an individual viewpoint. This philosophical family believes that realities explored by researchers are social products of the actors, of interactions and institutions (Flick, 2006). In this paradigm, researchers attempt to observe ongoing processes to better understand individual behavior and the spiritual nature of the world (Burrel & Morgan, 1979). Therefore, the researcher adopted social constructivism because of the understanding that mathematical knowledge construction in an individual and the process of integrating 21st Century Skills into mathematics teaching and learning takes effect from their societal practices because it involves real-life situations as well as classroom interactions. Further, to generate evidence on the integration of 21st Century Skills in the teaching and learning of mathematics, it was cardinal to affiliate to a social constructivist as this helped to unearth reality, knowledge and value attached to the teaching of 21st Century Skills. The researchers' intention was to make sense of the meanings others have about the world (Creswell, 2007:21).

3.3 Research Design and Approach

Research design is the process that involves the overall assumptions of research up to the method of data collection and analysis (Creswell, 2009). For Durrheim (2004:29), research design is a strategic framework for action that serves as a bridge between research questions and the execution, or implementation of the research strategy. In this regard, it can be said to be a progression of the study that led to the attainment of the stated objectives. This study employed a Case study research design. A case study is a type of qualitative research that convenes observations, interviews and documentary data to produce detailed and comprehensive accounts of different social phenomena. It is a means of harnessing the richness and depth of understanding of individuals, groups, and institutions; their beliefs and perceptions; their interactions; and their challenges and issues (Kuper and Hodges, 2008). In this study, case study research was used as the researcher sought to gain insight and ideas of the integration of 21st Century Skills (4Cs) in the teaching and learning process of the topic mensuration in grade eleven mathematics at the selected STEM Secondary School in Lusaka district. The teaching and learning process involves social interactions and as such case study is suitable for carrying out this study. Through its use in situation observations, the researcher was present in the social setting, thereby generating a rich understanding of social action. Participant observation also provided the researcher with an opportunity to gather empirical insights into the teaching and learning practices in the mathematics classroom which are normally 'hidden' from the public gaze. (Denzin and Lincoln, 2011; Merriam, 1988; Berry, 1991).

Weinreich (2009) elucidated that the purpose of qualitative research is to provide the researcher with the perspective of target audience members through immersion in a culture or situation and direct interaction with the people under study. This implies that in qualitative research, the researcher becomes an instrument of data collection, and results may differ greatly depending on who conducts the research. Therefore, the researcher conducted an in-depth study involving two secondary school mathematics teachers and two classes of grade eleven learners in a classroom setup. The researcher was present in both grade eleven classes from the start of the mathematics topic mensuration through to the end.

Qualitative methods include direct observation, document analysis and overview, participant observation, and open-ended unstructured interviewing. The aforementioned methods are designed to help researchers understand the meanings people assign to social phenomena and to illuminate the mental processes underlying behaviors. Qualitative methods in exploratory research involve the use of open-ended

questions and probing which gives the participants the opportunity to respond and add any remarks or explanations (Cresswell, 2009). Open-ended questions have the ability to evoke responses that are meaningful. This research aims to investigate Mathematics teachers' classroom practices in the context of 21st Century Skills; how Mathematics teachers integrate 21st Century Skills, specifically the 4Cs (Critical thinking, Creativity, Collaboration, and Communication), into their classroom practices. It is prompted by the issue of learners not acquiring these 4Cs effectively in the context of mathematics education. Therefore, the researcher recognized the need to explore and understand the complexity of the teaching and learning process in the mathematics classroom in the context of 21st Century Skills.

3.4 Study Sample and Sampling Technique

Sampling is an essential aspect of framing data collection and analysis activities, particularly in case study research, where the focus is often on a few cases or a single setting to facilitate in-depth study. In this study, the targeted population included grade eleven teachers and learners of mathematics at a selected National STEM Secondary School in Lusaka District. The study sample consisted of two regular teachers of Mathematics and two classes of grade eleven learners (53). Participants, activities, and interactions were purposefully sampled to generate a comprehensive picture of the integration of 21st Century Skills in a mathematics classroom. The study employed a non-probability sampling technique to select regular teachers of Mathematics in Lusaka District, following the elucidation by Denscombe (2003) that emphasizes the non-random selection of people or events in non-probability sampling. The purposive sampling technique, also known as judgment sampling, involves the deliberate choice of informants based on specific qualities they possess (Tongco, 2007).

In this study, a homogeneous type of purposive sampling was employed, meaning that participants were chosen because they shared a specific characteristic or set of characteristics relevant to the research focus (Cresswell, 2014). The researcher obtained information from the head of the mathematics departments in the target STEM school to identify teachers teaching grade eleven mathematics at the time of the research. The shared characteristic among the participants was their role as regular mathematics teachers teaching grade eleven mathematics and their respective learners at the targeted National Secondary STEM School in Lusaka District. This specific characteristic ensured that the selected participants had direct experience and involvement in the integration of 21st Century Skills in the mathematics classroom, aligning with the research objectives.

3.5 Data Collection Methods

The researcher utilized a qualitative research data collection method that guided the selection of appropriate research instruments which included; semi-structured interviews, lesson observations, performance assessment and document analysis. All these research instruments resulted in triangulation of the data. Robson (2002), described triangulation as a means of using diverse methods to collect data on the particular phenomena thereby letting findings to be compared and then collaborated or questioned accordingly. According to Patton (1990), triangulation guides against inconsistencies in data and ensures credibility. The purpose of triangulating is to provide a confluence of evidence that breeds credibility (Bowen, 2009). Patton (2002) argued that the combination of methods complements each other by eliminating overlapping flaws. Triangulation therefore implies that measurements from varied methods result in greater credibility.

3.6 Research Instruments

A research instrument is a tool used to collect, measure, and analyze data related to your subject. Research instruments can be tests, surveys, scales, questionnaires, as well checklists. The research instruments that were used in this study included: semi-structured interviews, lesson observations, performance assessment and document analysis. The quality of these instruments was very critical because "the conclusions researchers draw is based on the information they obtain using these instruments" (Fraenkel & Wallen, 2003). Each of the data collection methods are explained below (Creswell, 2014).

Semi-structured interviews (refer to Appendix 1): the first set of interviews was on teachers' knowledge of 21st Century Skills; collaboration, communication, creativity and critical thinking. Two regular teachers of mathematics were interviewed in this study. The second set of semi-structured interviews (refer to Appendix 3) was on how teachers of mathematics integrate 21st Century Skills in their classroom practices in secondary schools in order to better understand how teachers in schools were engaging and developing learners 21st Century Skills. The second set of interviews was conducted after the lesson observation. This method of interviewing did not use fixed questions, but aimed to engage the interviewee in conversation to elicit their understandings and interpretations" (Liamputtong & Ezzy 2005, p.332).

Lesson observation (refer to Appendix 2) focused on the observations of the 4Cs; communication, collaboration, creativity, and critical thinking using the Outcomes for P21 Math Skills Map which was in

form of a checklist of indicators of the 4Cs (Partnership for 21st Century Skills, 2008). Lesson observations provided the opportunity to monitor or assess a process or situation and document evidence of what was seen and heard. Seeing actions and behaviors within a natural context, or as they usually occurred provided insights and understanding of the event, activity or situation being evaluated. The audio and video documents were transcribed, coded and analyzed on the number of observed skills.

Performance assessment (refer to Appendix 5) was given to the learners after completion of lessons on mensuration in order to determine learner acquisition of the 21st Century Skills; communication, collaboration, creativity and critical thinking. In this study, the teachers designed questions for the learners based on lessons learnt throughout the mathematics classroom. All learners, a total of (53) learners from both classes A and B were subjected to the classroom-based assessments which included: exercises, group/pair work, classroom discussions and other tasks assigned to the learners during mensuration instruction. Classroom observations were conducted with the help of a guide on what to observe with regards to learner's exhibition of the 4Cs. Assessments can be designed to measure targeted dimensions of creativity. The most useful assessments elicit observable evidence and allow learners to demonstrate the highest forms of the 4Cs within a content area (Brandt, 2021). Evidence Centered Design (ECD) views an assessment as an evidence-based argument, using things that learners say, do, or create to make inferences about the extent of their knowledge, skills, and abilities (Mislevy & Haertel, 2007).

Document analysis (refer to Appendix 4) is a form of qualitative research in which documents are interpreted by the researcher to give voice and meaning around the phenomenon. It involves a systematic approach for reviewing or evaluating documents (Bowen, 2009). Documents review was based on the extent to which problem solving, applications, modelling and investigations are represented in the documents which include; syllabus, teaching materials, lesson plans, records of work, and schemes of work, learner worksheets and assessment tools on learners' 4Cs in order to determine how teacher participants record their information in line with 2013 curriculum framework, mathematics syllabus 10-12. Learner work samples were analyzed. An examination of the lesson plans and learner work products provided insight into effective development of learners' 21st Century Skills in a variety of contexts.

3.7 Data Collection Procedure

The researcher collected data during the third term of the Zambian school calendar, specifically, between October and November, 2022. Refer to Appendix 1 to 5 for each of the instruments. The semi-structured

interviews were conducted first because they provided a justification on knowledge of 21st Century Skills which is a priority that a teacher should possess in 21st century learning even before they go to teach in the classroom. Lesson observations followed through because, they provided guidance for the rest of the methods that followed afterwards. They provided information that needed to be followed up in the succeeding data collection methods. The semi-structured interviews (the second set) were followed up on the observations and hence further elicited information needed for the research on how 4Cs are integrated in the teaching and learning of mathematics. The performance assessments were used in investigating the extent to which the learners have acquired the 4Cs after a series of mathematics lessons on a particular topic. The question of what we want to know conducts us to think about the nature of what is to be assessed. However, the utmost challenge in measurement of most human social and cognitive capacities is the underlying ability that predicts how each of us behave and can perform is itself unseen. This underlying ability, or construct, is what we need to comprehend because we cannot measure the generic ability directly, constructs such as problem solving, critical thinking, collaboration, and communication, can be measured through tools that are designed to capture indicators of these skills (Care et al., 2018). Therefore this study involved the use of rubrics (Appendix 2 and 5) to collect data on each of the 4 Cs during classroom observation as well as performance assessment.

3.8 Data Analysis

This section describes the methods used for data analysis in this study. Bogdan and Biklen (2007, p. 159) described data analysis, in the context of qualitative research, as "the process of systematically searching and arranging the interview transcripts, field notes and other materials to increase your individual understanding of them and to enable you to present what you have discovered to others". In other words, data analysis refers to examining what has been collected in research and making deductions and inferences (Patton, 2002). Qualitative data collected from two regular teachers of Mathematics and two classes of grade eleven learners was analyzed using content analysis. Creswell (2014) asserted that content analysis is a research tool used to determine the presence of certain words, themes, or concepts within some given qualitative data. Sources of data could be from interviews, open-ended questions, field research notes, conversations, or literally any occurrence of communicative language (such as books, essays, discussions, newspaper headlines, speeches, media, historical documents). A single study may analyze various forms of text in its analysis. To analyze the text using content analysis, the text must be coded, or broken down, into manageable code categories for analysis. Once the text is coded into code

categories, the codes can then be further categorized into “code categories” to summarize data even further.

Data from semi-structured interviews, lesson observations, document analysis and researcher made tests was closely examined to identify code categories. The data that was obtained in this study was first broken down into units and then the units were categorized. The data collected was analyzed in three aspects of: description, analysis and interpretation. Description refers to the recounting and describing of data, inevitably treating the data as fact. Analysis refers to the process of examining relationships, factors and linkages across the data points. Finally, the interpretation of data builds an understanding or explanation of the data beyond the data points and analysis.

There are two general types of content analysis: conceptual analysis and relational analysis. This study will employ conceptual analysis which determines the existence and frequency of concepts in a text. Coding systems consist of rules for assigning specified units into categories. In this study, sequences of actions are inferred to represent particular skills, as well as direct actions. To begin a conceptual content analysis, the researcher first identified the research question and chose a sample or samples for analysis. Next, the text must be coded into manageable content categories. This is basically a process of selective reduction. By reducing the text to categories, the researcher focused on the code for specific words or patterns that inform respective research questions (Bengtsson, 2016). The steps involved in content analysis are summarized in the diagram below:

Appendix 2 shows the 21st century learning and innovation skills, their meanings and their indicators. An example of the data analysis process is given in *Table 3.8*, five themes that emerged were generated as shown in table 3 and these were: teacher limited knowledge of assessment, establishing learners’ prior knowledge, teacher feedback and assessment, questioning techniques, and lack of regular teacher training on 21st Century Skills.

Lesson observations	Semi-structured interviews	Document analysis	Performance assessment
• Teacher A mostly encouraged learners to work in groups/pairs. • For both Teacher A and B, the diagrams of the solids were poorly drawn. • For most of the lessons, both teachers did not carry the solids to class. • The only form of technology used was scientific calculators in both classes A and B. • Teacher B, the learners have a negative attitude during collaborative	• Both Teacher A and Teacher B had very little information about assessment • Teacher A and B both brought out technology as the main 21st century skill but did not know how to integrate it in the classroom. • Teacher A did not attend any training on implementation of the 2013 curriculum framework. • Teacher A and B, questions should be able to provoke critical thinking in the learners.	• Teacher A and B wrote down the lesson outcomes in the lesson plans. • Teacher A and B wrote down the prerequisite knowledge and skills in the lesson plans. • Mostly Teacher Bs' lesson plans included the field/career in which the topic is necessary. • The curriculum lacked guide lines on performance assessment rubrics.	• Teacher A gave feedback to the learners that instilled critical thinking. • Both Teacher A and Teacher B regarded exercises as the main form of assessment. • Teacher A and Teacher B mostly gave the learners exercises that were detached from reality. • Teachers A and B did not use performance-based assessments. • Learners in both classes portrayed a negative attitude towards learning mathematics

Table 3.8: Example of how themes were generated

3.9 Trustworthiness

This section is concerned with some of the ways in which quality can be achieved when conducting qualitative research and how quality can be demonstrated in qualitative research outputs (Creswell, 2009). Therefore, in this study, the researcher relied on four characteristics; credibility, transferability, confirmability and dependability as suggested by Denzin & Lincoln (2011).

3.9.1 Credibility

Credibility addresses the need to ensure that the data are interpreted appropriately and to "deal with the patterns in their entirety but to take certain actions that take account of the complexities" (Creswell, 2009). Several actions were taken to enhance the credibility of my study. These included briefing with my report supervisor, prolonged engagement with my participants, using more than one interview criteria to clarify or expand on findings, and keeping notes to track decisions and rationale.

3.9.2 Transferability

Transferability speaks to the ability to transfer findings from data to other settings. Additionally, it addresses the qualitative researcher's belief that all social/behavioural phenomena are context bound or context relevant (Kasonde-Ng'andu, 2013). This study demonstrated transferability by using purposive sampling to "maximize the range of information uncovered. Collection of "thick", rich, descriptive data, including the use of field notes on processes observed during the conversation and clear descriptions of the selection of the participant group used in the study were demonstrated. Ultimately, the purpose was not to transfer my findings to other studies, but rather to clarify understanding of the phenomena from the perspective of participants.

3.9.3 Dependability

Dependability of qualitative studies addresses the concern for the data to remain stable over time and in various conditions (Bryman, 2012). This study demonstrated dependability by providing descriptive details of methods used to gather, analyse, and interpret data. The authenticity of the data were clarified with participants and interpreted, examined, and discussed with the study supervisor.

3.9.4 Confirmability

Confirmability is the final step in demonstrating trustworthiness, and refers to the "objectivity or neutrality of the data" (Denzin and Lincoln, 2011). The current study addressed confirmability by establishing an audit trail consisting of such records as interview transcripts, reflective journaling following interviews, notes on planned activities related to data analysis, and all drafts of reports and related studies reviewed.

3.11 Ethical Considerations

The participants were treated with respect by obtaining consent from them to be part of this study. Before participating in the study, the researcher made them understand what the researcher was doing and promised to share the findings with them for their reactions among others. The researcher ensured ethical considerations were effectively practiced by undertaking informed consent before data collection activities, ensuring anonymity of participants, and maintaining confidentiality and privacy of all data gathered. Clearance was obtained from the University of Zambia Ethics Committee, the Ministry of Education and the selected STEM Secondary School.

Informed consent is a mechanism for ensuring that people understand what it means to take part in a particular research study so they can decide in a conscious, deliberate way whether they want to participate or not. "Informed consent is one of the most important tools for ensuring respect for persons during research" (Creswell, 2009). During the seeking of consent from the participants, inclusive of teachers and learners, the researcher elaborated on the following: the purpose of the research, what is expected of a research participant, including the amount of time likely to be required for participation, expected risks and benefits (including psychological and social), the fact that participation is voluntary and that one can withdraw at any time with no negative repercussions, how confidentiality will be protected, the name and contact information of the local lead investigator to be contacted for questions or problems related to the research, the name and contact information of an appropriate person to contact with questions about one's rights as a research participant (the chairperson of the research committee). All this information was provided in a language and at an educational level that the participant can comprehend. Potential participants were competent to make a decision about being in the research, and free from coercion or undue inducement to participate by researchers or others.

3.12 Chapter summary

This chapter provides a detailed exposition of the research methodology employed in the study. It begins by elucidating the research paradigm, adopting a qualitative approach underpinned by social constructivism. This paradigm was chosen to understand the construction of knowledge and the integration of 21st Century Skills in mathematics education. The research design, characterized by a case study, allowed for an in-depth exploration of the integration of 21st Century Skills in grade eleven mathematics teaching. A case study facilitates immersive observation and analysis of classroom dynamics

and interactions. Sampling techniques are described, with homogeneous purposive sampling used to select grade eleven mathematics teachers and learners at a STEM Secondary School in Lusaka District. This approach ensured participants' direct involvement in integrating 21st Century Skills into mathematics education. Data collection methods included semi-structured interviews, lesson observations, performance assessments, and document analysis. Triangulation of data enhances the credibility and validity of the findings. The chapter outlines the research instruments employed, such as semi-structured interviews to probe teachers' knowledge and practices regarding 21st Century Skills integration, and lesson observations to capture classroom dynamics and learner outcomes.

A systematic data collection procedure was detailed, emphasizing sequential engagement with participants and methods to ensure comprehensive data gathering. Data analysis techniques, notably content analysis, are discussed, highlighting the process of identifying patterns and themes across interviews, observations, and documents. Trustworthiness considerations are addressed, including credibility, transferability, dependability, and confirmability, ensuring the integrity and rigor of the study's findings. Ethical considerations, such as obtaining informed consent, ensuring participant anonymity and confidentiality, and obtaining clearance from relevant ethics committees, were meticulously observed throughout the research process. This chapter served as a foundation for the subsequent analysis and discussion, providing clarity on the research methodology and ensuring the robustness and ethical integrity of the study.

CHAPTER FOUR

RESEARCH FINDINGS

4.1 Overview

This chapter presents findings of the study on Mathematics Classroom Practices in the Context of 21st Century Skills. These findings have been presented in line with the research questions as presented in chapter one. The presentation of the findings begins with demographic profile of the research participants.

4.2 Demographic Profiles

4.2.1 Teachers' Demographic profile

Participants	Gender	Qualification	Teaching experience (Years)
Teacher A	M	Bachelor of Science (BSC) with Education	Four (4) years
Teacher B	M	Bachelor of Arts with Education (BAED)	Fourteen (14) years

Table 4.1.1: Demographic profile of the teachers who participated in the study. Source: Field data 2022

4.2.2 Learners' Demographic profile

Category	Number of Boys	Number of Girls	Age range
Class A	Twenty-nine (29)	Two (2)	14-17
Class B	Twenty-four (24)	Eight (8)	14-16

Table 4.2.2: Demographic profile of the learners who participated in the study. Source: Field data 2022

The table 4.2.2 above shows the categories and gender of the learner participants**.** It is evident from the table that there was a huge margin between the male and the female learners. The males had a higher representation than females in both category A and B. Nonetheless, this discrepancy did not affect the study owing to the fact that the study objectives were achieved, it instead enabled the researcher to generate rich information in a natural setting.

4.3 What constitutes teachers' level of understanding of 21st Century Skills; collaboration, communication, creativity and critical thinking towards teaching and learning mathematics at secondary school level?

The themes that were obtained from research question one were: Lack of adequate knowledge of 21st Century Skills among teachers; Teaching strategies; Teacher Awareness of the general outcomes of mensuration; Teaching style; Teachers lacked knowledge on integration of technology (technical know-how); and Teacher knowledge on collaborative tasks.

4.3.1 Technology as one of 21st Century Skills

During the interviews, the teachers were asked what skills society is demanding of citizens of today.

In response Teacher A stipulated that*:*

> The core value in the 2013 revised curriculum tailor a learner to cope up with the 21st century. (Teacher A)

This depicts that teachers are aware of the essentiality of the core values that are enshrined in the 2013 curriculum framework. However, it was vivid that both teacher participants keenly highlighted that technology is the main skill that the 21st century requires of an individual. This can further be drawn from Teacher A's statement in which he emphasized that:

> Technology is a skill that today's society demands as it is a 'world of computers'. One must be competent in the use of technology as the world we live in is going digital. (Teacher A)

This just shows that teachers acknowledge the importance of incorporating technology in the teaching and learning of mathematics as being one way of how learners will acquire the said skills.

Consistently Teacher B also insisted that:

> Technology is in high demand in our society today. The use of Information Communication and Technology (ICT) in our daily lives. The others such as problem solving, communications, and critical thinking have been there all along. Time is not enough especially when it comes to creativity and critical thinking activities, mostly slow learners lag behind. (Teacher B)

This statement points out the inadequacy of teachers' knowledge of how they can integrate the Learning and Innovation skills in the mathematics classroom while also considering time management. It also highlights the need to allocate more time to mathematics lessons.

However, Teacher A, on the importance of technology as a skill said:

> It bridges the gap between the abstract and the real world. (Teacher A)

This statement entails that teachers are aware of the 21st Century Skills as they were able to bring out communication, collaboration, creativity, and critical thinking in their perspectives. These skills are part of the Learning and innovation skills also known as the 4Cs. The reoccurring focus on technology by both teacher participants entails the need for integration of technology as well as the benefits of doing so which was revealed in a statement given by Teacher A who further went on record by stating that:

> It positively impacts the attitude of the learners as they can see the wide range of applications to real-life situations and thus learners will be able to appreciate mathematics as a subject. (Teacher A)

4.3.2 Teaching strategies

It was determined that during the first semi-structured interviews when asked about the teaching strategies that are expected from the teachers with regards to the 2013 curriculum, both teachers A and B had this to say:

Teacher B:

> If learners are not involved, they will not acquire the skills. (Teacher B)

Teacher A:

> Learner centered, learners should be active and should be at the center of all classroom activities. Learners learn best by doing. (Teacher A)

The above statements signify that individuals tend to learn and understand mathematics concepts and skills more effectively when they actively engage in the learning process rather than passively receiving information.

The two statements made by both Teacher A and B highlight the importance of learner involvement in learner acquisition of the learning and innovation skills. From the aforementioned statements, it is

apparent that the teacher is aware of the role that learners have in the 21st century mathematics classroom which entails that active learner participation is subsequent to meaningful learning. Hence through active participation in the teaching and learning process, learners will be able to acquire higher order skills such as communication, collaboration, critical thinking and creativity. It is also clear that teachers are aware that the mathematics classroom activities should be learner centered and that the teaching strategies should be driven by such. The aspect of learner centered teaching strategies are in harmony with what the 21st century curriculum instruction advocates for. Therefore, teaching strategies should indicate an instructional approach that aims to connect mathematical concepts, provide meaningful learning experiences, and engage learners actively in the learning process.

4.3.3 Teacher Awareness of the general outcomes of mensuration

During the semi structured interviews when the teachers were asked about the general outcomes of teaching the topic mensuration. Both teachers' responses were as follows:

Teacher A stipulated that:

> The learning outcomes of the topic mensuration would benefit the learners in terms of the careers they want to take up and examples include in engineering as well as manufacturing companies. The topic lays a foundation for the learners in preparing them for their future careers. Through the teaching and learning process, learners develop critical thinking skills as they work on the questions given in examples and exercises on mensuration. (Teacher A)

Teacher A's response highlights that the learning outcomes of mensuration benefit learners in terms of their future careers, particularly in engineering and manufacturing companies. The topic serves as a foundation for preparing learners for these career paths. Additionally, Teacher A emphasizes the development of critical thinking skills through the process of teaching and learning mensuration, specifically through working on examples and exercises. The aforementioned response reinforces the notion that mensuration helps learners enhance their spatial visualization abilities, problem-solving skills, measurement and accuracy competencies, as well as their understanding of geometry and technical communication. It suggests that the teaching and learning of mensuration fosters skills and knowledge that are highly applicable in engineering and manufacturing fields.

Teacher B responded:

> There are many benefits, the outcomes will be in other areas of life for example in tertiary institutions. (Teacher B)

Teacher B's response suggests that the outcomes of teaching mensuration extend beyond specific careers in engineering and manufacturing. They highlight that the benefits of learning mensuration can also be applicable in other areas of life, including tertiary education. While the response doesn't provide specific examples or elaborate on the outcomes in other areas, it implies that the skills and knowledge gained from studying mensuration can have broader applications beyond specific career paths. It suggests that the understanding of mensuration can be valuable in academic settings, potentially aiding learners in subjects such as mathematics, physics, architecture, or any field that involves measurement and calculation. Teacher B's response implies that the outcomes of teaching mensuration are not limited to career-focused benefits but can have a wider impact on various aspects of education and life.

The aforementioned responses reveal that both teachers are aware of the general outcomes of teaching mensuration. This is in alignment with the 21st century framework which emphasizes that teachers who are aware of the general outcomes of learning mensuration are well able to equip their learners with the necessary knowledge to succeed in various fields such as in engineering, architecture as well as construction.

4.3.4 Learner-centered teaching style

In the interviews, both teachers emphasized their teaching style being learner centered and the following is what they had to say:

Teacher A said:

> Learners should learn by guided discovery distinguished by the Teacher asking learners questions that elicit critical thinking as well as problem solving in them. I capitalize on what learners know and direct them towards understanding new mathematics concepts. (Teacher A)

The above statement means that the teacher knows that learners should be encouraged to discover knowledge on their own with the guidance of the teacher. In this instance the teacher illustrated that he knows his role as a teacher which involves asking learners questions that challenge them to think critically and solve problems rather than simply providing them with answers. This approach depicts constructivism

as the teacher stated that he capitalizes on what learners know and directs them towards learning new mathematics concepts. This approach encourages learners to actively engage in the learning process, develop their own understanding of the subject matter and apply their knowledge in practical situations. One of the teachers made mention of guided discovery and that it enables learners to become more independent, confident and capable of solving complex problems on their own and consequently learners tend to acquire high-order skills such as: communication, collaboration, creativity and critical thinking skills.

Teacher B said:

> If learners are not involved, they will not acquire the skills. (Teacher B)

The statement above entails that the teacher knows what teaching style to employ and certainly what is required of them for learners to acquire the necessary skills needed to succeed in the 21st century. Unlike the traditional teaching style where teachers simply impart knowledge to learners, in the 21st century classroom, learners need to be engaged in the learning process and take an active role in their learning. Therefore, if learners are not involved, they will not be able to acquire the 4Cs. Despite the teachers' understanding of the importance of a learner-centered teaching style, the evidence of implementing such practices in the classroom was limited. This suggests a gap between knowledge and practice in effectively fostering the acquisition of 21st Century Skills among learners.

4.3.5 Teachers' knowledge on integration of technology (technical know-how)

During the interviews, when teachers were asked which software if any were installed in the computer lab that can be used to teach the topic mensuration, Teacher A said:

> I am not sure; I will ask the computer lab custodian. Learners would really appreciate the use of learning using technology except that we teachers lack technical know-how and have not undergone any form of training in readiness to teach in a 21st century classroom. (Teacher A)

Teacher A's uncertainty about the software installed in the computer lab suggests a lack of awareness regarding the available resources. This may indicate a lack of communication and coordination between the teachers and the computer lab custodian or the relevant authorities responsible for managing the computer lab. The absence of clear communication channels can result in missed opportunities to utilize technology effectively for teaching and learning. In the latter statement, Teacher A's acknowledgment that learners would appreciate the use of technology indicates an understanding of the potential benefits of

incorporating technology in the classroom. However, the lack of technical know-how among teachers poses a barrier to effectively integrating technology into their teaching practices. Without proper training and support, teachers may struggle to leverage available technology resources to enhance instruction and engage learners. Therefore, the statement ushered by Teacher A suggests that the current teaching practices may lean towards a more traditional, teacher-centered approach rather than a learner-centered, technology-enhanced approach.

Teacher B said:

> An individual should be competent with how to use and apply technology. We are going digital and everything has to do with computers. We are lagging behind in in bridging the abstract to the real-world in mathematics. Usually teaching is more theoretical, the practical part is left out and hence learners cannot relate. (Teacher B)

Teacher B's response highlights the importance of technological competence among teachers, the need to bridge the gap between abstract mathematics and real-world applications, and the potential of technology to facilitate this bridging process. It also emphasizes the need to shift from purely theoretical mathematics instruction to a more practical and relevant approach. Integrating technology effectively can play a significant role in achieving these goals and enhancing learners' comprehension, engagement, and application of mathematical concepts. Technology tools, such as simulations, modeling software, and data analysis programs, can be utilized to bring real-world contexts into mathematics instruction, making it more tangible and meaningful for learners. Teacher B's statement suggests that learners may struggle to relate mathematics to their everyday lives due to the lack of practical applications explored in the classroom. When mathematics is taught primarily in a theoretical manner, learners may perceive it as disconnected from their real-life experiences. By incorporating technology and real-world contexts, teachers can enhance learners' ability to see the relevance and applicability of mathematics in their daily lives. During the interview, when asked whether the computer labs were functional, Teacher A stated that:

> The school has a well-furnished computer lab except that it is mostly accessed by learners taking computer studies. Now that the learners are done with the theoretical part of mensuration, they are now supposed to go to the computer labs for hands on learning activities where they can further interact with the visual aids of 2D and 3D objects. (Teacher A)

The presence of a well-furnished computer lab indicates that the school has the necessary infrastructure to support technology integration in education. However, the limited access to the lab by learners taking

computer studies suggests that other learners may not have regular opportunities to utilize these resources. Expanding access to the computer lab for other subjects, such as mathematics, allows learners to benefit from hands-on learning activities and interact with visual aids related to 2D and 3D objects in the context of mensuration. Visual aids play a crucial role in the comprehension of complex mathematical concepts, particularly in geometry and mensuration. However, by appropriately utilizing technology resources in the computer lab, learners can access visual representations of 2D and 3D objects, manipulate them, and observe their properties. This visual engagement helps them to develop spatial awareness, visualize concepts, and make connections between abstract mathematical ideas and real-world objects. Hands-on activities in the computer lab encourage active learning and collaboration among learners. They can work together in pairs or groups to explore and solve mensuration-related problems using the available technology tools. This collaborative approach promotes communication, critical thinking, and teamwork, as learners discuss and analyze their findings, compare strategies, and provide peer feedback. The interactive nature of technology-based activities enhances learner engagement and participation thus enabling learners to acquire the 21st Century Skills.

Though both teachers emphasized the importance of including technology in mensuration instruction, the classroom observations indicated otherwise as the only form of technological tool used during lessons was a calculator. The calculator was basically used to compute the values of the volumes and total surface areas of both 2D and 3D solids. This limits learner acquisition of higher-order thinking skills like creativity and critical thinking.

4.3.6 Teacher knowledge on collaborative tasks

During the interviews with the teacher participants, on the classroom tasks or activities they employ in the classroom, each teacher had this to say:

Teacher A*:*

> I am one who believes in team work. Through cooperative learning, learners can share ideas with each other and also helps learners who are lagging behind as this style ensures guided learning through peers. (Teacher A)

The statement emphasizes the teachers' belief in teamwork and the benefits of cooperative learning in the educational context. Cooperative learning encourages learners to work together in groups or teams, providing them with opportunities to share their ideas, perspectives, and knowledge. This collaborative

approach fosters active engagement, as learners actively participate in discussions, contribute their thoughts, and learn from each other. Through this process, learners can gain a deeper understanding of the subject matter by considering multiple viewpoints and collectively constructing knowledge. Engaging in cooperative learning activities allows learners to develop important social and interpersonal skills. It promotes active listening, respect for diverse perspectives, and the ability to work collectively towards a common goal. These skills are valuable not only in academic settings but also in various aspects of life, such as future careers and personal relationships. Cooperative learning encourages learners to engage in higher-order thinking skills, such as critical thinking and problem-solving. As they work together, learners are required to analyze information, evaluate different perspectives, and come up with creative solutions. This collaborative problem-solving approach helps develop learners' critical thinking abilities and prepares them for real-world challenges where teamwork and collaboration are often required.

Teacher B:

> It encourages the idea of learners working on their own and also working amongst themselves so that they can have confidence to explain to their friends. This inculcates the spirit of being able to communicate. Through solving a question together, learners develop the sense of listening skills and being able to share knowledge with each other. (Teacher B)

The statement highlights the importance of both individual work and collaborative work in fostering communication skills and knowledge sharing among learners. By engaging in individual work, learners have the opportunity to develop independent learning skills. They can take ownership of their learning, practice self-directed problem-solving, and develop the ability to work through challenges on their own. This heightens learners' independence and cultivates a sense of responsibility as well as self-confidence, they become more capable of tackling tasks and questions independently. This entails that through collaborative problem-solving, learners develop essential communication and teamwork skills. They learn how to express their ideas, actively listen to others, provide constructive feedback, and collaborate effectively towards a common goal. These skills are essential not only for academic success but also for future professional endeavors, as effective communication and teamwork are highly valued in various contexts. This inclusive approach allows learners to benefit from individual reflection and exploration while also valuing the contributions of their peers.

4.4 How aligned are mathematics teachers' classroom practices to fostering of learners' acquisition of 21st Century Skills?

Under research question two the themes obtained were: establish learners' prior knowledge; development of mathematical conceptual understanding and linkage to everyday life; limited use of technology during the teaching of mensuration; encouragement of use of several problem-solving strategies among the teachers; interactive classroom, exchange of ideas among learners; learner engagement; teaching strategy; lack of mathematics laboratory and questioning techniques.

4.4.1 Establish learners' prior knowledge

Teacher A began the lesson on the total surface area of a cone by building on the prerequisite knowledge of the learners on the area and circumference of a circle.

Teacher A asked:

Do you recall the formula of the area of a circle?

Learner A1 responded:

Area of a circle=πr^2

Teacher A further asked:

What about the circumference of a circle?

Learner A2 responded:

Circumference of a circle=$2\pi r$

The interaction between Teacher A and the learners in this scenario shows a teaching strategy that builds on the learners' prerequisite knowledge to introduce the concept of the total surface area of a cone. This approach has several implications for teaching and learning in the 21st century mathematics classroom. Building on prior knowledge is one of the implications, Teacher A initiates the lesson by tapping into the learners' existing knowledge of the area and circumference of a circle. By starting with a question about these concepts, Teacher A activates the learners' prior knowledge and establishes a connection between the new topic (total surface area of a cone) and what they already know. This approach helps to create a foundation for understanding and promotes meaningful learning.

Another implication is reinforcement of key formulas, the dialogue highlights the formulas for the area and circumference of a circle. By engaging the learners recalling and stating these formulas, Teacher A reinforces their understanding of these concepts. This reinforcement enhances retention and helps learners consolidate their knowledge of circle-related formulas, which are essential for understanding the total surface area of a cone. The interaction between Teacher A and the learners fosters an interactive learning environment. By asking questions and eliciting responses from the learners, Teacher A promotes active engagement and participation. This interactive approach encourages learners to think critically, recall information, and express their understanding, which deepens their learning experience and fosters a learner-centered classroom environment. It also creates a learner-centered learning environment that values learner input and fosters a sense of ownership over their learning. Through the classroom interaction, Teacher A can gauge their grasp of these concepts. This assessment helps Teacher A determine the learners' readiness to delve into the topic of the total surface area of a cone and identify any misconceptions that need clarification. By leveraging learners' prior knowledge, teachers can effectively introduce new concepts and support meaningful understanding.

While Teacher B on the volume and surface area of the cone included in the lesson plan on finding the area and circumference of a circle. Further, from the documents analysis, it was also evidenced in the lesson plans that both teachers started their lessons with prerequisite knowledge as shown in the figure below. During the lesson observation the teacher introduced the lesson by giving the learners an activity to find the area of a sector as shown in Figure 4.4.1 below:

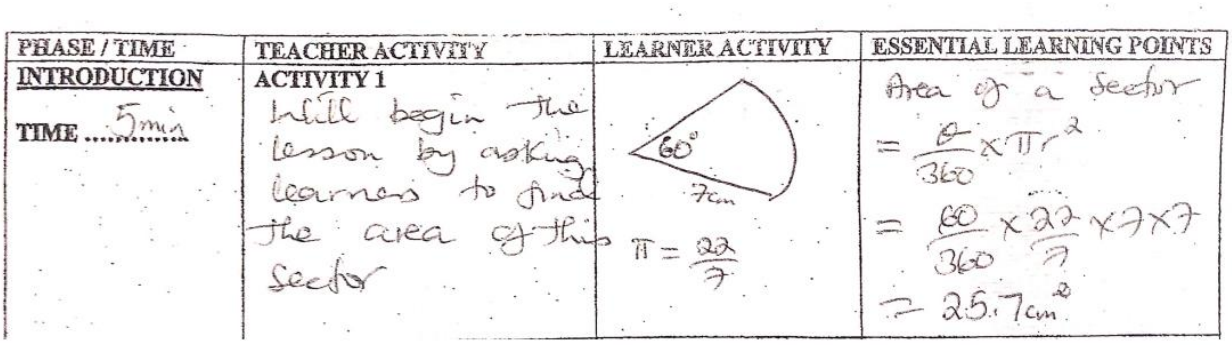

Figure 4.4. 1: A picture of the introductory section of a lesson by Teacher B.

Based on the figure above, it is clear that Teacher B included the volume and surface area of a cone in their lesson plan, building on the prerequisite knowledge of finding the area and circumference of a circle. This demonstrates a sequential approach where teachers connect new concepts to previously learned

material, enabling learners to make connections and deepen their understanding. The introduction of an activity to find the area of a sector suggests that Teacher B incorporated a hands-on approach to engage learners and facilitate active learning. By providing practical tasks related to the topic, learners can apply their knowledge in a real-world context, reinforcing their understanding and enhancing their problem-solving skills.

4.4.2 Development of mathematical conceptual understanding and linkage to everyday life

The study established that during lesson observation in classroom 11A on the introduction of the topic, the teacher made reference to real-life situations in the teaching of mensuration as depicted below:

When the topic mensuration was introduced, Teacher A asked:

> What do you understand by the term mensuration?

Learners responded in unison:

> Mensuration is about measurements

And further the Teacher asked them:

> Give real life examples where mensuration can be used.

The learners were able to give examples from their environment and everyday activities. They gave examples of food preparation:

> For example, making sugar solution

, the learner went on to say:

> You first measure the volume of water and then accordingly add a reasonable amount of sugar.

During the classroom observation, Teacher A gave an example:

> Those who were making these desks had to take into consideration the size of the classroom and how many desks can fit. If you bring in something bigger than the door it won't be able to enter.

The teacher further asked the learners:

> Why do we have to learn the concept of area? , give practical examples of where else can mensuration be used

And probing the learner, the teacher mentioned the use of mensuration to farmers. The learner responded:

> The size of the land. If you know the area of the land, you will know the amount of seed to buy.

Learner A1 responds:

> Estimation…not exact.

Teacher A responds to the learners:

> Not exactly yes but we estimate almost exact, so we learn all these things to be able to estimate and make better decisions. Through these examples we can see that mathematics is applied in real-life.

The above information demonstrates how Teacher A incorporated real-life situations and examples into the teaching of mensuration. This method involves contextualizing the subject matter by prompting learners to offer real-life instances where mensuration finds application. Teacher A effectively contextualizes the topic, making it pertinent to the everyday lives of the learners. It presents an approach helps learners connect abstract mathematical concepts with practical applications, enhancing their understanding and motivation to learn. During the lesson, the learners actively participated in the discussion by providing examples from their environment and everyday activities. This engagement promotes a learner-centered learning environment where learners contribute their knowledge and experiences, fostering a sense of ownership over their learning. Through the given examples of food preparation and desk size consideration, Teacher A demonstrates how mensuration is applied in practical situations. This highlights the usefulness of mathematics in solving real-world problems and decision-making, helping learners recognize the importance of learning mensuration. Therefore, by discussing real-life situations where mensuration is applied, Teacher A promotes the development of problem-solving skills. Learners are encouraged to think critically, analyze situations, and apply their mathematical knowledge to solve problems. This approach nurtures learners' ability to transfer mathematical concepts to different contexts and enhances their problem-solving capabilities.

The mention of estimation by Learner A1 and the subsequent explanation by Teacher A emphasize the importance of estimation in practical applications of mensuration. Learners understand that exact measurements may not always be feasible or necessary, and estimation can help in making informed decisions. This concept of estimation enhances their mathematical reasoning skills and encourages them

to consider practical constraints when applying mensuration. Teacher A's statement, "Through these examples we can see that mathematics is applied in real-life," highlights the relevance and meaning of mathematics in learners' lives. By connecting mathematical concepts to real-world applications, Teacher A helps learners appreciate the practical value of mathematics beyond the classroom, fostering a positive attitude towards the subject.

4.4.3 Technology use during the teaching of mensuration

The only form of technology that was eminent was the use of scientific calculators by the learners when finding values such as the total surface area and volumes of both 2 and 3 Dimension objects.

While limited use of technology may have benefits, it's also worth considering how incorporating other technological tools or resources could enhance the teaching and learning of mensuration. Utilizing interactive geometry software, virtual simulations, or online resources can provide visualizations, exploratory experiences, and real-world applications that complement the manual calculations and further engage learners.

Overall, the limited use of technology, primarily in the form of scientific calculators, during the teaching of mensuration allows learners to develop their mathematical skills, deepen their conceptual understanding, improve mathematical reasoning, and focus on fundamental skills. However, exploring additional technology options can provide further opportunities for visualization, exploration, and application of mensuration concepts in the 21st century mathematics classroom.

4.4.4 Encouragement of the use of several problem-solving strategies by the teachers

During one of the lesson observations, Teacher A encouraged the use of two methods 1 and 2 when finding the volume of the frustum of a cone. After the teacher had worked out examples with the learners, he gave them an exercise and said:

> You are going to work out the solutions of the exercise given using both methods 1 and 2 for each question. Do the work in pairs and submit it for marking individually.

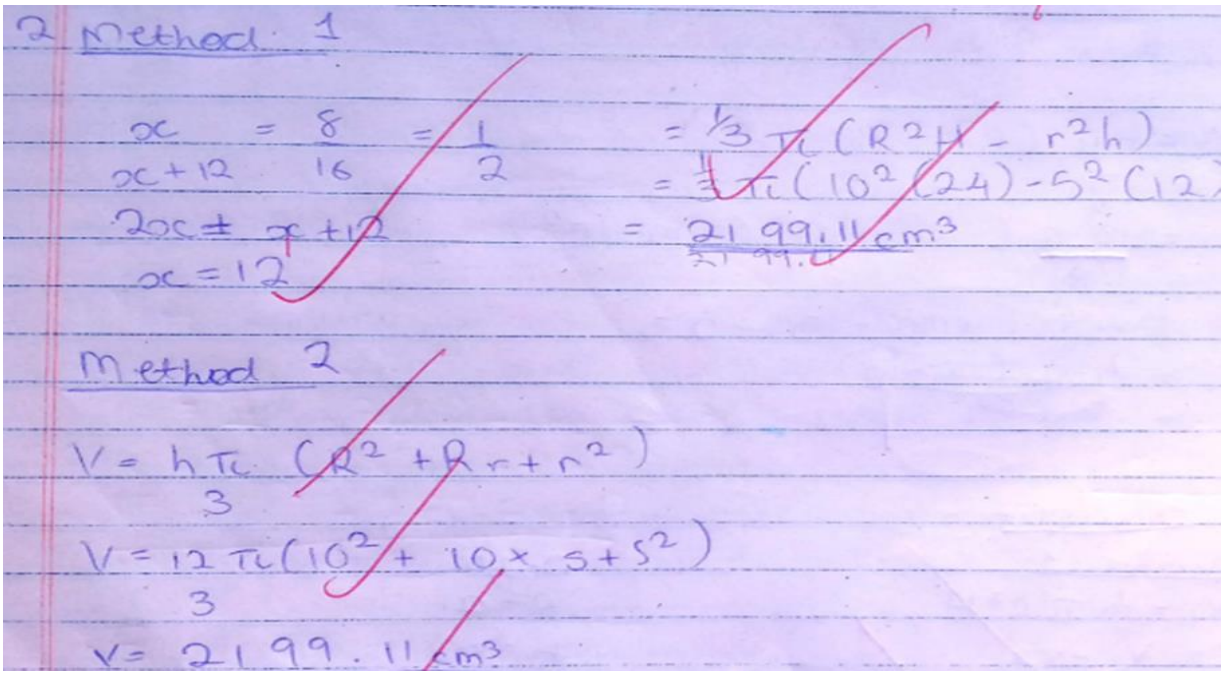

Figure 4.4.4: A picture captured from a learners' book of a question on finding the volume of a frustum of a cone solved using two methods 1 and 2.

As shown in the figure above learners solved each of the given questions in their books using method 1 and 2 as instructed by Teacher A in class A.

Teacher A's approach of encouraging the use of multiple problem-solving strategies, specifically methods 1 and 2, during the lesson observation can have several benefits for the learners. This approach encourages comprehensive understanding, by using different methods to solve problems, learners are exposed to different approaches, techniques, and thought processes. This promotes a deeper and more comprehensive understanding of the topic. It allows learners to explore different perspectives and solutions, enabling them to grasp the underlying concepts from various angles.

Through the encouragement of the use of multiple problem-solving strategies, learners are able to develop critical thinking and reasoning. It stimulates critical thinking skills as learners are able to analyze and evaluate the advantages and limitations of each method, compare their results, and justify their approaches. This process helps develop their logical reasoning abilities and fosters a deeper engagement with the subject matter and mathematical concepts.

By working in pairs to solve the exercise using both methods, learners have the opportunity to collaborate and engage in discussions. They can compare their approaches, explain their reasoning to each other, and

discuss the similarities and differences between the methods. This collaborative problem-solving enhances their communication skills and encourages active participation in the learning process.

By utilizing multiple problem-solving strategies, learners develop a repertoire of skills that can be applied to various mathematical problems. The ability to choose and apply different methods based on the problem's characteristics enhances their problem-solving versatility. This skill transfer extends beyond mensuration, benefitting learners in other areas of mathematics and real-life situations. However, Teacher A's approach promotes a holistic learning experience by encouraging learners to explore different problem-solving strategies. It fosters a deeper understanding, critical thinking, collaboration, and the development of transferable skills. By engaging with multiple methods, learners can build a solid foundation in mensuration and develop problem-solving abilities that can be valuable in their academic and professional lives.

During one of the lesson observations, Teacher B wrote down an example, he used two methods 1 and 2 when finding the volume of a frustum of a cone. Teacher B later emphasized on the use of one of the formulae while saying:

> It’s easier and faster, do not use both methods. (Teacher B)

In the case of Teacher B, emphasizing the use of one formula as easier and faster can be appropriate in certain situations. It can streamline the learning process and help learners develop efficiency in their problem-solving approach. However, it's crucial to ensure that learners still understand the underlying principles and can apply alternative methods when necessary. In summary, encouraging the use of multiple problem-solving strategies in mensuration can benefit learners by enhancing their understanding, promoting flexibility, engagement, and transferable skills.

4.4.5 Interactive classroom

Teacher A during the lessons provided the necessary guidance by going round while learners do the work in pairs. Learners during the discussion assume shared discussion assume shared responsibility for the work given. In addition, the teacher gives learners an opportunity to present their findings and also encourages various problem-solving strategies for teaching a knowledge point which was noticeable through the two formulas for finding the volume of the frustum of a cone as the Teacher Allowed the learners to use the two formulae

The learners suggested that to find the formula of the frustum of a cone, you first have to find the volume of the whole cone minus what remains after the top part has been removed. The learners were able to find the formula with the teachers' guided assistance where learners were probed, for instance, the Teacher Asked generally:

> What is needed and what could be missing to find the volume of the larger cone to which the learners responded; the height = $x + 60$.

Further on, the Teacher asked a follow up question:

> What should we do to find the value of the height of the larger cone?

The learners were then reminded by Teacher A*:*

> You can use similarity and congruence, explain why.

The learners then responded:

> The two cones can be represented by two triangles (a big one and a smaller one) and hence the value of the height would be found.

Teacher B:

> If you know how to solve the volume of the cone, so here we are going to assume that it is full so the first thing we are going to do here let us draw, we are going to have something like this. (Teacher draws a full cone and then rubs off the top part leaving a drawing of the truncated or frustum of a cone)

Teacher B:

> We do not know what the volume of the frustum is but we know the volume of a cone.

The description provided highlights several key aspects of an interactive classroom environment. In this instance the aspect of guided assistance and shared responsibility was eminent where Teacher A went around the classroom while learners worked in pairs, providing necessary guidance and support. This approach encourages learners to take shared responsibility for their work and fosters independent thinking while still receiving teacher guidance when needed. The teacher gives learners the opportunity to present their findings. This not only allows learners to showcase their understanding but also promotes communication and presentation skills. Teacher A encourages various problem-solving strategies by allowing learners to use different formulae for finding the volume of the frustum of a cone. This approach promotes critical thinking and flexibility in approaching mathematical problems. Teacher A engages

learners through probing questions, such as asking what is needed and what could be missing to find the volume of the larger cone. This prompts learners to analyze the problem and articulate their reasoning. The teacher's follow-up question about using similarity and congruence further challenges learners to think critically and make connections between different mathematical concepts.

Teacher B connects the concept of finding the volume of the frustum of a cone with the learners' knowledge of finding the volume of a cone. This integration of prior knowledge helps learners make connections and apply their existing understanding to new concepts. The interactive classroom described promotes active engagement, critical thinking, and collaborative problem-solving among learners. The teacher's guidance, encouragement of multiple strategies, and opportunities for presentations contribute to a rich learning experience where learners are actively involved in constructing their mathematical knowledge.

4.4.6 Exchange of ideas among learners

During the lesson's observations on the total surface area of a cone, learners articulated their mathematical thoughts and ideas both orally and in writing. For instance, when learners were asked to work in pairs

Learner A1:

Which formula did you use?

Learner A2:

No, we should use the slant height to find the total surface area of a cone.

The observation of learners exchanging ideas during the lesson on the total surface area of a cone indicates active engagement and collaboration among themselves. The above conversation between Learner A1 and Learner A2 demonstrates the sharing of strategies as Learner A1 initiates the discussion by asking their partner which formula they used. This suggests that learners are encouraged to share and compare their approaches to problem-solving. By sharing their strategies, learners can learn from each other and gain a deeper understanding of the topic. Learner A2 responded by stating that they should use the slant height to find the total surface area of a cone. This indicates that learners are considering multiple approaches to problem-solving and discussing their merits.

By discussing different methods, learners can evaluate and justify their choices, leading to a richer exploration of the topic. The exchange between Learner A1 and Learner A2 reflects a collaborative

problem-solving process. They are engaging in a dialogue to determine the most appropriate formula or method for finding the total surface area of a cone. This collaborative approach encourages active participation, critical thinking, and the development of communication skills. Therefore, the exchange of ideas among learners during the lesson observation signifies a classroom environment that promotes collaboration and encourages learners to articulate their mathematical thoughts and ideas. It fosters a sense of shared responsibility for learning and provides opportunities for learners to learn from each other's perspectives and approaches. Such exchanges contribute to a deeper understanding of the concepts and enhance the overall learning experience.

4.4.7 Learner engagement

Teacher A first draws a cone and then draws a cut cone. He then asks the learners:

> Based on what we are doing here, we started with a cone.

Then he asks the learners:

> So we are looking at the volume of the frustum, now who can come up with the definition of a frustum?

Learner A1:

> A cone that has its top cut off.

Learner A2:

> A truncated cone.

Teacher A responds:

> But then you need to generalize. Teacher draws a cone on the board. So even this one, you can cut off and what remains is still called a frustum.

Teacher then asked the learners

> What do you call a pyramid that has its top cut off? How can you define a frustum? Give the definition in form of a pyramid.

Learner A4:

> This is a shape which has a base as a circle and it doesn’t have an arc length.

Teacher A:

> You used the word circle, what shape is this?

Learner A4 responds while pointing at the drawing of the pyramid:

> That is a square,

The Teacher Asks:

> Is this a cone?

Learners respond

> No

The teacher further asks:

> This is a what?

And some learners responded:

> A square

While others responded:

> A square pyramid

Learners respond:

> Pyramid

The teacher then gives definition based on the learners' answers:

> This is a part of a cone or a pyramid that remains if the top is cut off. In the case of a frustum of a cone, we had something that looked like this. (Teacher draws a frustum of a cone/ truncated cone).

The observations in Teacher A's classroom highlight the teacher's efforts to engage learners in understanding the concept of a frustum and its relationship to cones and pyramids. Teacher A begins by asking the learners to come up with a definition of a frustum. Learner A1 responds by stating that a frustum is a cone that has its top cut off. Learner A2 adds that it is a truncated cone. However, the teacher encourages the learners to generalize the definition by drawing a cone on the board and demonstrating that cutting off the top portion results in a frustum. This indicates the teacher's intention to help learners understand that a frustum can be formed from various shapes, including cones and pyramids.

Teacher A further extends the discussion by asking the learners to define a frustum in terms of a pyramid. Learner A4 responds by describing a frustum as a shape with a circular base and no arc length. The teacher then prompts the learner to identify the shape of the base, and the learner points to the drawing of a square pyramid. The teacher reinforces the correct response that the shape is a pyramid and uses the learners' answers to provide a definition: a frustum is a part of a cone or a pyramid that remains when the top is cut off. By engaging the learners in defining and understanding the concept of a frustum, Teacher A promotes learner engagement and active participation in the lesson. The teacher encourages learners to think critically, generalize their understanding, and make connections between different geometric shapes. This approach fosters a deeper comprehension of the topic and promotes mathematical reasoning and communication skills.

4.4.8 Teaching strategy

Teacher A mostly emphasized classroom discussions and pair work throughout his lessons. Consequently, as the lessons progressed, the learners in class A were able to work effectively by sharing and critiquing each other's ideas.

Learner A1:

When finding the volume of a cone did you use π or 3.142?

Learner A2:

No, I used π

Learner A1:

Okay let's also use 3.142 and see if we are going to get the same values.

This teaching strategy is cardinal in the 21st century mathematics classroom and it advocates for active learner engagement. Therefore, different instructional strategies complement each other and provide a holistic learning experience. By incorporating classroom discussions and pair work, Teacher A introduces a diverse range of learning experiences. This can cater for different learning styles and preferences among learners. Some learners may excel in verbal expression, while others might benefit from collaborating with a partner. This approach promotes inclusivity and accommodates individual differences in the classroom as learners are provided with time to collaborate and capitalize on each other's skill as well as refine their problem-solving processes.

4.4.9 Lack of mathematics laboratory

The researcher asked the teachers about the presence of a mathematics laboratory in the school, and the teachers' response was:

Teacher A:

> There is no mathematics laboratory here regardless of it being a national school. We only have computer labs. And for the solids that were used for mensuration lessons, we store them in the mathematics department. (Teacher A)

He further went on to state that*:*

> Learners would appreciate the topic mensuration more if they are taken to a mathematics laboratory where they can interact with solids as well as on computers and hence from there learners can be given real-life scenarios as this will enable them to move from the abstract world to the physical world. (Teacher A)

The lack of a mathematics laboratory in the school, as mentioned by Teacher A, has several implications for the teaching and learning of mensuration in a 21st century mathematics classroom. Without a mathematics laboratory, learners miss out on the opportunity to engage in hands-on activities and interact directly with mathematical objects and solids. Hands-on experiences are crucial for developing a concrete understanding of geometric concepts, such as mensuration, and bridging the gap between abstract mathematical ideas and the physical world. Hence the absence of practical learning experiences in the classroom can be attributed to the lack of a mathematics laboratory in the school.

Teacher A also mentioned storing solids used for mensuration lessons in the mathematics department. While it's positive that the materials are available, the lack of a dedicated mathematics laboratory may result in limited accessibility and organization of these resources. A mathematics laboratory would provide a designated space to store and display a variety of mathematical tools, manipulatives, and solids, making them easily accessible for both teachers and learners.

Generally, the absence of a mathematics laboratory inhibits the hands-on and practical learning experiences necessary for a deeper understanding of mensuration. It limits opportunities for learners to engage with mathematical objects, explore real-life scenarios, and utilize technology effectively. Establishing a mathematics laboratory would provide a dedicated space for interactive learning, enhance learners' engagement and understanding of mensuration, and bridge the gap between abstract

mathematical concepts and real-world applications. Therefore, the presence of a mathematics laboratory in the school would enhance learner acquisition of 21st Century Skills.

4.4.10 Questioning techniques

In one of the lesson observations in classroom A, Teacher A asked the learners:

> Why is there no pi (π) in the formula for the volume of a frustum of a pyramid?

The learners responded:

> There is no circle on the pyramid.

In another instance during lesson observation in 11A, it was found that Teacher A probed the learners on finding the volume of the frustum of a cone as depicted in the conversation between the Teacher And the learners below:

Teacher A:

> In fact, this one is method number one, then we know that this is the top part which was cut off. So now from here to here what is the height?

Learners respond:

> It is 60cm

Teacher responds:

> Okay, this is the radius here which is how many centimeters?

Learner A2:

> 20cm

Teacher A:

> Then we also have this radius here which is?

Learners respond:

> 40cm

Teacher A:

> Then there is this part here, what is the height of that ka cone which we have added?

Learners respond:

> We don't know.

The teacher redirects learners:

> That is now the issue of variables coming into play. We can just name it as x. I want someone to tell me, what is the height from here up to there of the full cone?

Learners respond in unison:

> $x + 60$

Teacher A:

> Our target is to find the value of x. Let's discuss, how can we get the value of x there?

Learner A4:

> Now Sir, where does that part come from the x?

Teacher clarifies:

> In our definition we said that a frustum is a what? that part which remains when the top part has been cut off. But we know that it was cut off right?

Learner's answer:

> Yes.

When Teacher A asked why there is no π in the formula for the volume of a frustum of a pyramid, and the learners responded by stating that there is no circle on the pyramid. This suggests that the learners recognized that the formula for the volume of a frustum does not involve π because the frustum does not have a circular cross-section. Further on, Teacher A probed the learners to identify the dimensions of the frustum of a cone, such as the height, radii, and the unknown height of the added cone. The learners were able to provide some measurements, such as the height being 60 cm, one radius being 20 cm, and the other radius being 40 cm. However, they were uncertain about the height of the added cone. In a quest to address the unknown height, Teacher A introduced the concept of variables, naming the height of the added cone as x. This demonstrates the teacher's attempt to introduce algebraic thinking and problem-solving strategies to find the value of x. Teacher A prompted the learners to discuss and figure out how to find the value of x. Learner A4 raised a question about the relationship of x to the given information, indicating a

need for clarification. The teacher explained the concept of a frustum and emphasized that it is the remaining part after the top has been cut off.

Overall, the conversations suggest that Teacher A employed a discussion-based approach to help the learners understand the volume of a frustum of a pyramid or cone. The teacher encouraged the learners to think critically, make connections between mathematical concepts, and engage in problem-solving strategies. By exploring the concept of variables and applying geometric principles, the learners were challenged to find the value of x, thereby promoting their mathematical reasoning and problem-solving skills.

4.5. How are classroom-based assessments as administered by mathematics teachers aligned with 21st Century Skills?

Further on, under research question three, the themes obtained include: the curriculum lacked clearly defined rubrics on performance assessment; teachers had limited knowledge on the forms of 4Cs assessment; lack of practical experiences in the classroom; lack of mathematical challenging tasks and teacher feedback to the learners and assessment. The researcher collected data from document analysis, lesson observations and semi-structured interviews.

4.5.1 The curriculum lacked clearly defined rubrics on performance assessment

During document analysis it was revealed that despite the emphasis on the 4Cs as key competences in the Zambian 2013 curriculum framework, this has not been translated into clearly defined implementation plans, descriptions of appropriate teaching strategies, or development of well-designed assessment tools. However, the 2013 curriculum, emphasizes the use of clearly defined rubrics (or criteria) to facilitate a fair and consistent assessment of learner's work.

4.5.2 Limited knowledge on the forms of 4Cs assessment

Both Teacher A and B referred to classroom exercises as the only form of assessment given to the learners and tests which are given occasionally. And during document analysis, it was revealed that the content of the exercises was consistently characterized by close ended questions which required learners to find the values of the volume and total surface area of 2 and 3 Dimensional solids.

During the interviews on assessment with regards to achieving of the outcomes of grade eleven mathematics, Teacher B said:

> The questions should be designed in such a way that they are able to provoke critical thinking, abstract thought and spatial visualization in order for learners to think in a certain way. (Teacher B)

In the statement above Teacher B emphasizes the importance of designing questions that provoke critical thinking, abstract thought, and spatial visualization. This indicates an awareness of the need for assessments that go beyond rote memorization and basic comprehension. However, the statement does not necessarily indicate a deep understanding of the full spectrum of 4Cs (Critical Thinking, Communication, Collaboration, Creativity) assessment. While critical thinking is one aspect of the 4Cs, the statement doesn't explicitly address the other dimensions.

Teacher A articulated:

> Learners should be given the space, if possible, to allow them to connect concepts on their own and should not be told answers. (Teacher A)

Teacher A highlights the importance of allowing learners the space to connect concepts on their own without simply providing them with answers. This reflects an understanding of the value of student-centered learning and inquiry-based approaches. Similar to Teacher B's statement, Teacher A's statement focuses on promoting critical thinking and independence among learners. However, it also does not explicitly address the other dimensions of the 4Cs assessment framework.

In summary, while both Teacher A and Teacher B show some awareness of aspects related to critical thinking and student-centered learning, their statements do not fully encompass the breadth of the 4Cs assessment framework. This demonstrates teachers' lack of deeper knowledge or application of assessment methods that foster all dimensions of the 4Cs: Critical Thinking, Communication, Collaboration, and Creativity. Thus, their statements suggest a limited understanding of the various forms of assessment that can effectively measure these skills in the mathematics classroom.

4.5.3 Lack of practical experiences in the classroom

During the lesson observations, it was eminent that in spite of the stress on Outcome Based Education (OBE) in the Zambian 2013 curriculum framework, learners in both classes were not given any form of hands-on experiences during the teaching and learning of mensuration.

The study also revealed that both teachers in their lesson plans did not include practical experiences for learners as shown in the diagram below:

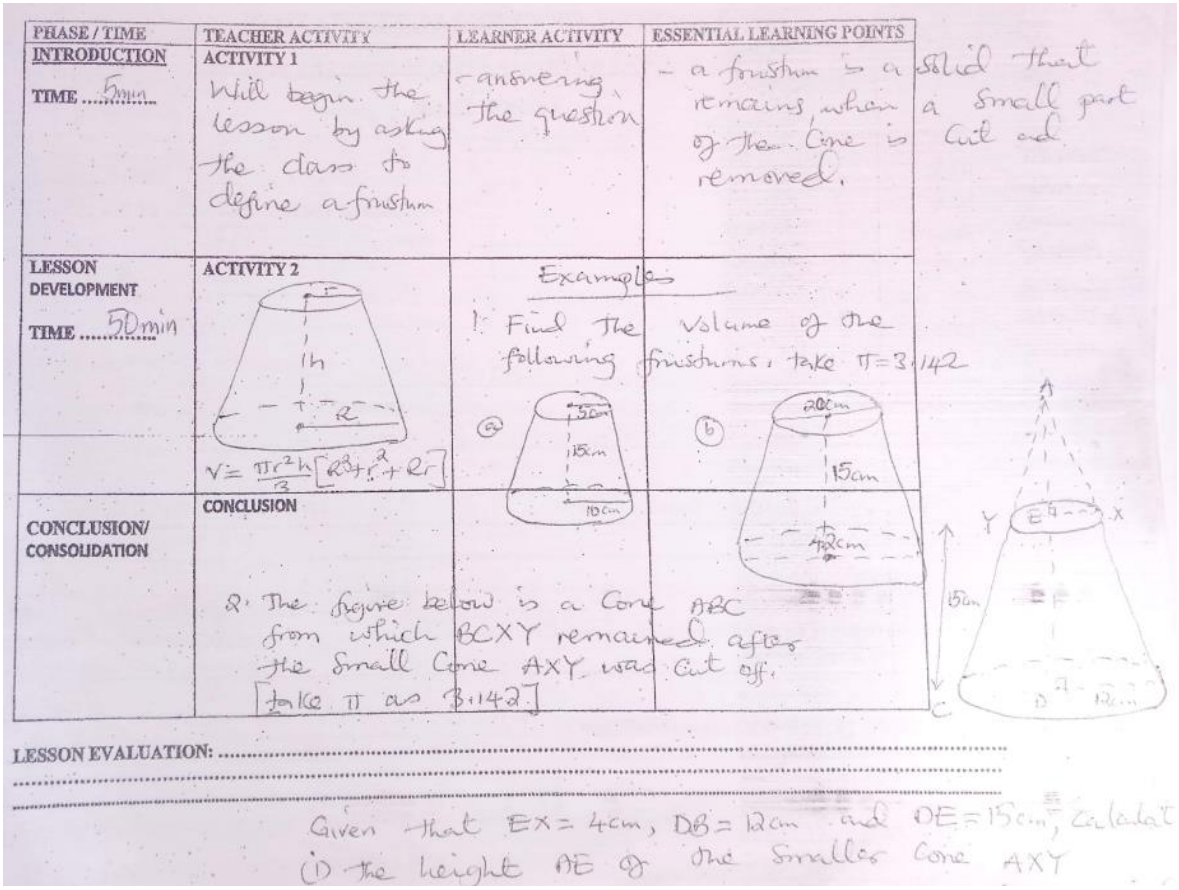

Figure 4.3.3: Teacher A's lesson plan showing the lack of inclusion of practical experiences.

Most lessons were characterized by: firstly, Teacher A provided a formula for a particular concept followed by its definition on the concept of a frustum of a cone without providing any practical learning experiences. However, hands-on learning experiences allow learners to apply their knowledge in real-world situations as this help them to better understand and remember what they have learned. It also helps to develop practical skills as well as problem solving. Hands-on learning experiences have numerous

benefits for learners, including better understanding and retention of knowledge, development of practical skills, and enhancement of problem-solving abilities. Such learning experiences are worthwhile as they provide learners with opportunities to apply theoretical knowledge in the real-world contexts. By engaging in practical activities related to mensuration, such as measuring objects, constructing geometric shapes, or solving real-life problems involving area, perimeter, or volume, learners can see the direct application and relevance of the mathematical concepts they are learning. In addition, practical experiences in mensuration foster the development of practical skills such as measuring accurately, using appropriate tools and instruments, and making estimations. These skills are valuable not only in mathematics but also in various real-life situations, such as construction, engineering, and design.

4.5.4 Lack of mathematical challenging tasks

Learners were not given challenging enough tasks that when worked on can elicit learner acquisition of the 4Cs. This was observed in both classes. In most cases learners were expected to use the given formulas to find the values of volumes and total surface of 3 D solids

During lesson observations in class B on the volume and total surface area, it was evident that the teacher wrote down the formulas and gave examples on how to use the formulas given can be used to find the volume, area and total surface area as shown in the figure below.

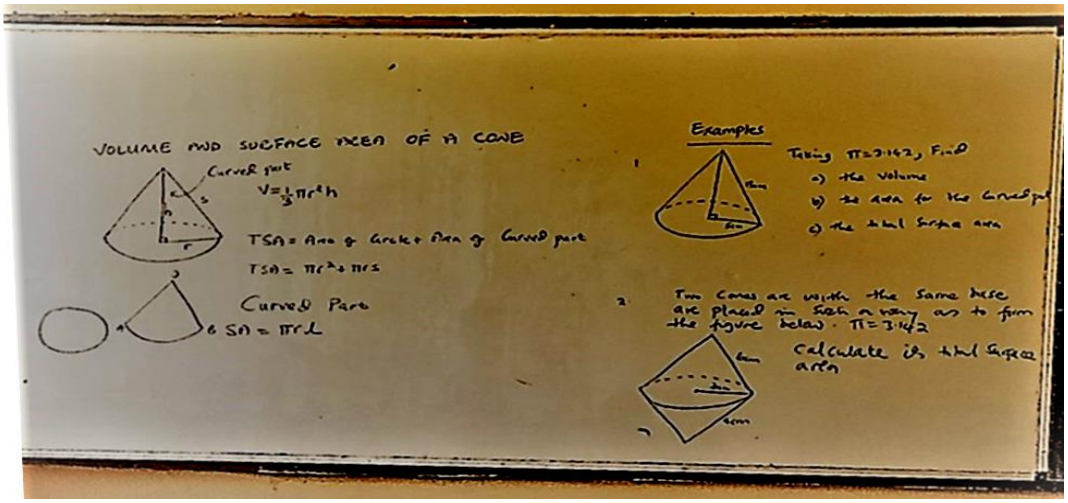

Figure 4.5.4: Depicts formulas written down on finding the surface area and volume of a cone and follow-up example questions.

4.5.5 Teacher feedback to the learners

During lesson observation on the volume of a frustum of a cone in classroom B it was found that Teacher B went round to check the learners work after giving them a task and instructed them to work in pairs. Teacher B approached one of the pairs of learners and asked them:

> You must find the volume of the shape that remains after the top part of the cone has been cut off.

In this instance, the feedback provided by the teacher was aimed at guiding the learners on what the task given requires of them.

Teacher B then went on to ask the pair (learner B1 and learner B2)*:*

> What the bigger R and what the smaller r is?

Here the teacher is not giving answers but instead he gave the learners ideas to work with by asking the learners probing questions thereby engaging them in higher order thinking. He further asked the pair:

> What is the height?

Teacher B then tells the learners:

> The height is five.

The earlier statement entails that the teacher tells the answer to the learners instead of giving them ample time to solve the problem on their own. This may consequently compromise the learners' acquisition of creativity and critical thinking skills.

However, during document analysis, it was determined that both teachers did not give feedback in the learners' books as shown in the Figure 4.5.5 below. This trend was evident in some of the classroom A and B learners' books. For instance, in the diagram below the teacher marked the diagram below wrongly without including a comment to act as a guideline for the learner. And during the lesson observation, the teacher did not make follow ups on the learners who got the work wrong instead the teacher would just revise the questions using the formulas and also encourage learners to master the formulas. This nullifies the sole purpose of feedback as this does not address the learners' misconceptions and misunderstandings of mathematics concepts. Thereby compromising 21st century education which aims at enabling learners' mastery of the skills communication, collaboration, creativity and critical thinking (4Cs).

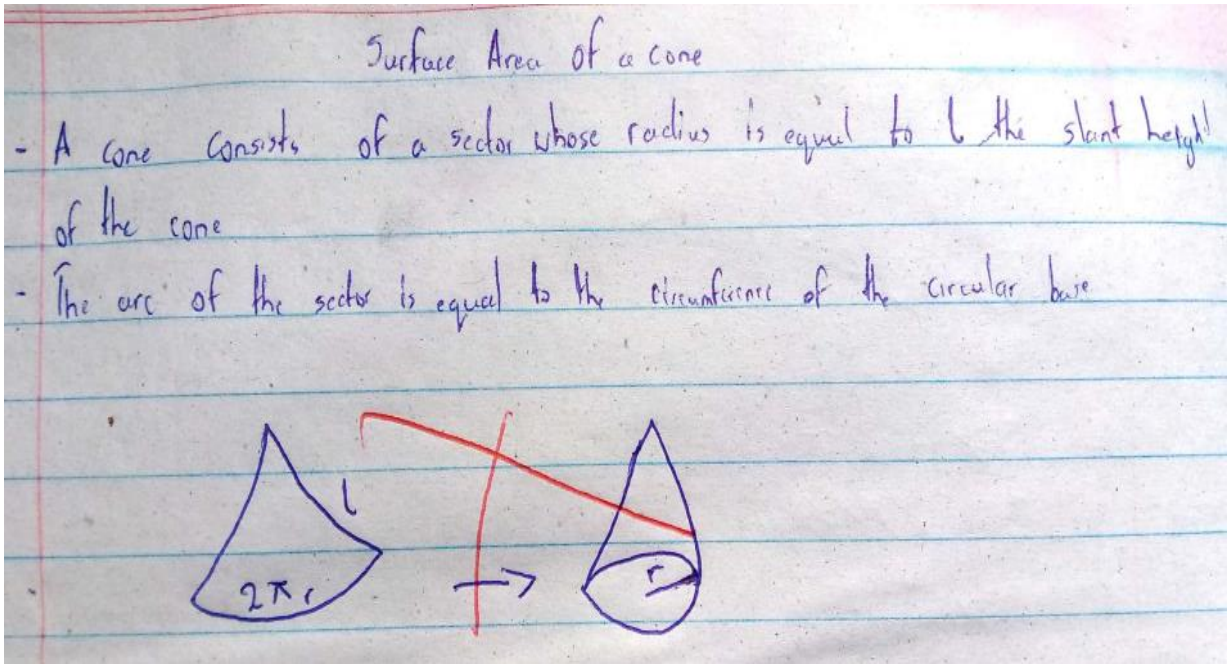

Figure 4.5.5: A picture captured from a learners' book where the teacher marked the work wrong and did not give feedback to the learner.

4.6 What challenges do mathematics teachers say they face in line with teaching for learners' acquisition of 21st Century Skills?

During the study, conducted at a selected secondary STEM school in Lusaka district, both teachers highlighted numerous challenges they encountered while teaching mensuration, which could potentially affect the integration of 21st Century Skills into mathematics classroom practices. These challenges encompassed limited access to computers and inadequate computer training, insufficient support from school management, overwhelming classroom sizes, emphasis on syllabi completion, scarcity of teaching and learning materials, restricted time allocated for mathematics lessons, unfavorable learner attitudes, and infrequent teacher training workshops on 21st Century Skills. The teachers also proposed potential solutions to these issues, including acquiring updated teaching materials, conducting more regular teacher training workshops on 21st century education, deploying additional teachers, enhancing support from school management, increasing the number of mathematics periods, motivating both learners and mathematics teachers. These collective challenges profoundly impact the efficacy of mathematics instruction and the overall learning journey of learners within the 21st century classroom. Effectively

addressing these challenges necessitates collaborative efforts among educators, administrators, policymakers, and stakeholders to ensure a high-quality mathematics education for all learners.

4.6.1 Limited computers and no computer training

> The computers are limited and mostly we teachers should undergo training so as to enable us to make use of such resources. Learning would be more interesting as learners will interact with graphic designs 3D and 2D objects. Meaningful learning would occur. (Teacher A)

During the semi-structured interviews, when teachers were asked which software if any were installed in the computer lab that can be used to teach the topic mensuration, Teacher A said:

> I am not sure; I will ask the computer lab custodian. (Teacher A)

Teacher A went on to say:

> Learners would really appreciate the use of learning using technology except that the teachers lack technical know-how and have not undergone any form of training in readiness to teach in a 21st century classroom. (Teacher A)

Limited computers and the lack of computer training pose significant challenges to the integration of technology in mathematics education. As highlighted by Teacher A, the limited availability of computers restricts the opportunities for teachers to incorporate technology resources and tools into their lessons. Without access to an adequate number of computers, teachers may find it challenging to provide hands-on learning experiences that engage learners and enhance their understanding of mensuration concepts.

Moreover, the lack of computer training further compounds this challenge. As Teacher A emphasized, teachers require the necessary technical know-how to effectively utilize computer resources and software in the classroom. Without proper training, teachers may feel hesitant or ill-equipped to integrate technology into their teaching practices, resulting in missed opportunities for interactive and engaging learning experiences. The potential benefits of incorporating technology in mathematics education are significant. With access to computers and appropriate training, teachers can leverage graphic design software and interactive 3D/2D objects to create meaningful learning experiences for their learners. These resources can facilitate visualizations, simulations, and real-life applications of mensuration concepts, fostering a deeper understanding and engagement among learners.

Unfortunately, the lack of computer training and limited access to computers hinder the realization of these benefits. As Teacher A acknowledged, teachers have not undergone any form of training in preparation for teaching in a 21st-century classroom. This highlights the importance of providing teachers with professional development opportunities specifically focused on integrating technology in mathematics education. By equipping teachers with the necessary skills and knowledge, they can confidently utilize available technology resources and create dynamic learning environments that promote critical thinking, problem-solving, and collaborative skills among learners.

In conclusion, addressing the challenges of limited computers and the lack of computer training is essential to enhance the integration of technology in mathematics education. By increasing access to computers and providing comprehensive training programs for teachers, schools can empower educators to effectively utilize technology resources and create engaging learning experiences in the context of mensuration.

4.6.2 Lack of support from school management

Furthermore, both teachers raised a concern in relation to support from the school administration, and this is what they highlighted;

> There is biasness by the head Teacher because they do not appreciate the role of mathematics in the society, they tend to be inclined to the subjects they teach other than mathematics. (Teacher B)

This bias can result in a lack of emphasis on mathematics within the school curriculum and a diminished importance placed on the subject. Consequently, teachers may feel undervalued and unsupported in their efforts to promote mathematics education.

> Due to lack of administration support, mostly mathematics tends to be overshadowed by other subjects as this affects the learners' attitudes towards the subject and as such learners will not be able to appreciate it fully. (Teacher A)

Both teachers emphasized the lack of support from school administration as a significant challenge in the implementation of effective mathematics classroom practices. Teacher B pointed out a bias by the head teacher towards subjects other than mathematics, indicating a lack of appreciation for the role of mathematics in society. Subsequently, this bias can result in a diminished emphasis on mathematics within the school curriculum and a reduced importance placed on the subject as a whole. As a consequence, teachers may feel undervalued and unsupported in their efforts to promote mathematics education.

Additionally, Teacher A highlighted that the lack of administration support often leads to mathematics being overshadowed by other subjects. This imbalance affects learners' attitudes towards mathematics, as it receives less attention, resources, and time compared to other areas of the curriculum. The limited support and attention given to mathematics can hinder its growth and development as a subject. Learners may not receive the necessary support and encouragement to fully appreciate mathematics, leading to disengagement and negative attitudes towards the subject.

Generally, this means that resources, time, and attention may be disproportionately allocated to other areas of the curriculum, leaving mathematics with limited opportunities for growth and development. As a result, learners may not receive the necessary support and encouragement to fully appreciate the subject, leading to disengagement and negative attitudes towards mathematics.

4.6.3 Classroom overload and emphasis on syllabi completion

During the first semi-structured interviews, when Teacher B was asked if there was anything he can add on that he felt would enhance the discussion with regards to the skills that society is demanding today. His response was:

> We are able to teach these things very well but there is a challenge. We are overwhelmed with classes and that affects adequate planning. (Teacher B)

Teacher B further stipulated:

> There is so much emphasis on completion of the syllabus and the target aim is for learners to pass the exams. In the teacher educator programs, the values are taught. Effective learning requires teachers to be patient with the learners. (Teacher B)

Teacher B stipulated:

> Effective teaching requires a teacher to be patient with the learners so as to also accommodate the slow learners thereby ensuring that all learners acquire the necessary skills through the teaching and learning process. (Teacher B)

During lesson observation it was revealed that teachers emphasize on examinations. Teacher B in one of the lessons stated that:

> If you fail to understand a question like this, 6 marks is gone from your final exams. These types of questions normally come, so I'm encouraging you to pay attention and ask where you are not clear. (Teacher B)

Teacher B expressed concerns about classroom overload and the emphasis on syllabus completion in education. They highlighted the challenge of being overwhelmed with classes, which hampers adequate planning. Despite being capable of teaching essential skills, the pressure to complete the syllabus and focus on exam results is prioritized. Teacher B also mentioned that teacher educator programs emphasize the importance of values in teaching. They emphasized that effective learning requires teachers to be patient with learners and accommodate the needs of slow learners. This approach ensures that all learners acquire the necessary skills during the teaching and learning process.

During a lesson observation, it was evident that teachers put a strong emphasis on examinations. Teacher B specifically mentioned that failing to understand a particular type of question would result in the loss of six marks from the final exams. This statement highlights the importance placed on exam performance and the motivation for learners to pay close attention and seek clarification when needed. Overall, Teacher B's statements reflect the challenges faced by educators in balancing the demands of completing the syllabus and focusing on exam results while also considering the needs of individual learners and effective teaching practices.

4.6.4 Teaching and learning materials

During the interview with the teachers on teaching and learning materials, Teacher B had the following to say:

> Ever since the implementation of the 2013 curriculum framework, there has not been much changes in terms of text books. The new text books lack proper guidance for the teachers. We still use the older books because they have better questions and they provoke critical thinking amongst leaners. The pre-requisites are not included for instance in the topic mensuration, the area and circumference of 2D shapes like a circle making it difficult on the part of the learner to connect the concepts. In this sense logic constructivism is contradicted. (Teacher B)

Teacher B further went on record to say:

> In as much as the syllabus is less congested, some pre-requisites are omitted. In terms of the benefits of the learner, they have created gaps in knowledge. (Teacher B)

According to Teacher B, the implementation of the 2013 curriculum framework has resulted in inadequate teaching and learning materials. The new textbooks lack proper guidance for teachers, leading them to continue using older books that are deemed more effective in stimulating critical thinking among learners.

One specific issue is the omission of pre-requisites in certain topics, such as mensuration. For instance, the new textbooks fail to include the necessary foundational knowledge for understanding the concepts of area and circumference of 2D shapes like a circle. This omission hinders the learners' ability to make connections and contradicts the principles of logic constructivism, which emphasizes the importance of building knowledge on existing foundations.

From the perspective of Teacher B, although the syllabus may be less crowded, the omission of pre-requisites creates gaps in the learners' knowledge. This situation poses challenges to both teachers and learners, as they struggle to bridge these gaps and develop a comprehensive understanding of the subject matter.

4.6.5 Limited time allocated to mathematics lessons

During interviews with the teachers, teacher B on time allocated to mathematics lessons stated that:

> In a case where the head teacher is not a mathematics teacher, they tend to be more inclined to other subjects which generally affects learners because mostly the periods allocated to mathematics are less. (Teacher B)

According to Teacher B, in cases where the head teacher is not a mathematics teacher, they may prioritize other subjects over mathematics. As a result, the time allocated for mathematics lessons tends to be limited. This preference for other subjects by the head teacher can have negative consequences for the learners. With fewer periods allocated to mathematics, learners may not have enough time to fully engage with the subject and develop a strong understanding of mathematical concepts and skills. This limitation in time can hinder the learners' progress and achievement in mathematics. It is important for schools to ensure that all subjects, including mathematics, receive sufficient time and attention in the curriculum to provide learners with a well-rounded education.

4.6.6 Learners' attitudes

From the first interviews which the researcher conducted with each of the two teachers who participated in this research, Teacher B had this to say in an interview with the researcher on general outcomes of education:

Researcher: during the lesson, what was the essence of asking learners to write their solutions on the board?

In response to the aforementioned question, Teacher B stated:

> Mostly learners find it difficult to express themselves, they tend to be shy. When called to the board to present their solutions, learners just solve and fail to communicate their ideas verbally. This shows that learners are not willing to create a conducive environment for participation. Learners have a negative attitude as some do not bring books for marking. This affects the process of feedback. (Teacher B)

Teacher B's statement above shed light on several important aspects of the learning environment within the 21st century mathematics classroom. Firstly, the challenge of communication emerges as a significant hurdle for learners, as many struggle to express their ideas verbally when called upon to present solutions. This highlights the need for fostering effective communication skills among learners, which are essential not only for mathematical discourse but also for success in various aspects of modern life where communication plays a vital role.

Moreover, Teacher B's observation regarding the reluctance of learners to actively participate in classroom activities suggests a broader issue of student engagement. In the 21st century, classrooms aim to cultivate environments where learners are encouraged to actively contribute, collaborate, and engage with the material. Overcoming barriers to participation is crucial for creating dynamic and interactive learning spaces where learners feel empowered to share their ideas, ask questions, and explore mathematical concepts together.

Additionally, the negative attitudes displayed by some learners, as evidenced by their failure to bring books for marking, reflect a broader challenge of fostering a positive learning culture within the classroom. In the 21st century, classrooms strive to cultivate environments where learners feel motivated, valued, and supported in their learning journeys. Addressing negative attitudes and promoting a culture of accountability and responsibility among learners is essential for creating a conducive learning atmosphere where feedback can be effectively utilized to support learner growth and development.

Generally, Teacher B's insights underscore the importance of addressing communication challenges, promoting active participation, and fostering positive attitudes within the 21st century mathematics classroom. By prioritizing these elements, educators can create engaging and inclusive learning environments where learners are empowered to communicate effectively, actively participate in learning activities, and cultivate positive attitudes towards their academic pursuits.

4.6.7 Teacher training workshops on 21st Century Skills are rarely conducted

Solutions on the problem of mathematics teachers' knowledge on integration of 21st Century Skills were spelt out by teachers A and B; this is what they said:

> These people in the forefront of this revised curriculum should organize workshops for all of us to attend and learn more on 21st Century Skills especially technology and how they can effectively integrate it in the teaching of mathematics. I have never attended any training or workshop on how to teach mathematics with regards to the 2013 curriculum ever since I joined the ministry of education in 2018. (Teacher A)

> I started teaching in 2008, after the 2013 curriculum was effected, we have only had workshops that were held in zones and only run for two weeks. The workshop content was not subject specific. Therefore, I recommend that these curriculum specialists should teach us about 21st Century Skills for instance technology and how it should be implemented, so that we implement it well even in the teaching of mensuration. (Teacher B)

The statements made by teachers A and B highlight the lack of training and workshops specifically focused on integrating 21st Century Skills, especially technology, into the teaching of mathematics. Some potential solutions to address this problem include: Organizing workshops dedicated to training mathematics teachers on the integration of 21st Century Skills in the teaching of mathematics. These workshops should provide hands-on training, practical examples, and resources specifically tailored to mathematics education. The workshops offered should be subject-specific training sessions that focus on the application of 21st Century Skills in mathematics. These sessions should cover topics such as using technology tools, incorporating real-world contexts, promoting critical thinking and problem-solving, and fostering collaboration and communication skills within the mathematics classroom. This provides ongoing professional development opportunities for mathematics teachers, including regular workshops, seminars, or online courses. These opportunities should be designed to keep teachers updated on the latest research, pedagogical strategies, and technological advancements relevant to 21st Century Skills in mathematics education.

Collaboration with curriculum specialists should also be considered with curriculum specialists and experts in mathematics education to design and deliver training programs specifically addressing the integration of 21st Century Skills in the teaching of mathematics. These specialists can provide valuable insights, resources, and guidance to support teachers in effectively incorporating 21st Century Skills into their instructional practices. Therefore, mathematics teachers should be encouraged to participate in peer

learning communities or professional learning networks where they can exchange ideas, share best practices, and learn from each other's experiences in integrating 21st Century Skills into mathematics teaching. This can be facilitated through online platforms, teacher forums, or regular meetings. By implementing these solutions, education authorities can better equip mathematics teachers with the knowledge and skills necessary to effectively integrate 21st Century Skills, including technology, into their teaching practices. This will ultimately enhance the quality of mathematics education and better prepare learners for the demands of the 21st century.

4.7 Chapter summary

This chapter has presented the findings on mathematics teachers' classroom practices in the context of 21st Century Skills. It was found that teachers of mathematics were aware of the 21st Century Skills except that they deemed technology as the most important skill in the 21st century society. Both teachers had knowledge on general outcomes of education and they established learners' prior knowledge. This study established that there is dire need for elaborate materials on how to integrate 21st Century Skills in the teaching and learning of mathematics. There is also need to increase number of periods for mathematics lessons and conduct regular teacher training workshops on 21st Century Skills. Both teachers did give real life examples to the learners, however, the class activities on the outcomes of each lesson did not link class activities to overall outcomes of 21st century education. This can be attributed to lack of learner's practical experiences. Teachers asked learners to solve on the board and some of them gave group work to their learners. Teachers did not provide challenging tasks for their learners during the teaching of mensuration. The teachers highlighted some problems that they encountered during the teaching of mensuration and some of these are: limited computers and no computer training; lack of support from school management; classroom overload and emphasis on syllabi completion; inadequate teaching and learning materials; limited time allocated to mathematics lessons; learners' attitudes and teacher training workshops on 21st Century Skills are rarely. They also gave what they thought could be solutions to the problems they mentioned and these were: purchase updated teaching and learning materials, conduct regular teacher training workshops more on 21st century education, more teachers to be deployed, improved support from the school management, increase the number of mathematics periods, motivate learners as well as teachers of mathematics. The following chapter will give a discussion of the findings that have been presented in chapter 4.

The study revealed that in order to mitigate the aforementioned challenges, teachers mentioned that school managements should purchase mathematics teaching and learning materials, learners should be motivated to learn mathematics, number of periods for teaching mathematics should be increased, conduct workshops on the integration of 21st Century Skills in the mathematics classroom, more elaborate materials should be prepared, link mensuration to real life problem solving, government to deploy more mathematics teachers and need for management to support teachers of mathematics. In addition, during the classroom observation it was eminent that learners in both classes A and B came late for lessons especially that both classes had most of their lessons scheduled after lunch. This also attributed to having many learners absent for mathematics lessons.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 Overview

This chapter discusses the findings of the study on Mathematics Classroom Practices in the Context of 21st Century Skills. The implications of the findings are discussed with the literature in support and at variance.

5.3 Teachers' awareness of 21st Century Skills

This section discusses the findings of the study on the first research objective which focused on understanding what comprises of teachers' awareness of the 21st Century Skills. The discussion is based on themes that emerged and these were: lack of adequate knowledge of 21st Century Skills among teachers; limited teaching strategies; Teacher Awareness of the general outcomes of teaching mensuration; teaching style; teachers lacked knowledge on integration of technology (technical know-how) and teacher knowledge on collaborative tasks.

5.3.1 Lack of adequate knowledge of 21st Century Skills among teachers

Based on the responses given by the participants and observations made during teaching and learning of mathematics, findings give an impression that teachers had inadequate knowledge about 21st Century Skills. The only 21st century skill that teachers were aware of is technology as one teacher mentioned that technology is a skill that today's society demands as it is a world of computers. Thus, it is necessary for one to be competent in the use of technology as the world we live in is going digital (Partnership for 21st Century Skills, 2008). Despite technology being an important skill in the teaching and learning of mathematics, a study done by Care et al., (2018) brings to the fore some of the 21st Century Skills which teachers should focus on when teaching mathematics ranging from communication, creativity, critical thinking, and problem solving. Equally, these four skills are the most frequently identified within national policy documents of the 152 countries which included Zambia. These skills are important in the sense that Mathematics is a dynamic discipline that is ever expanding as new ideas are contributed hence, learners should be able to elaborate, refine, analyze and evaluate ideas to improve one's own creative efforts (Brandt, 2021). During the interviews, one of the respondents stated that time is not enough especially

when it comes to creativity and critical thinking activities, mostly slow learners lag behind. However, Gasser (2011) stipulated that instruction can still be fast-paced and standards do not have to be neglected in order to place great focus on communication, collaboration, problem solving and critical thinking skills. Therefore, this illuminates the dire need for teachers training on how to incorporate the 4Cs in the teaching and learning classroom practices.

The semi-structured interviews separately conducted with each teacher revealed that both of mathematics teachers possessed enough conceptual understanding of 21st Century Skills, and both of them were aware of some of the methods however they lacked assessment strategies that incorporate the 4Cs as well as implementation of some of the 4Cs which include creativity and critical thinking. Teachers had very little information about assessment of the 4Cs and both had difficulties in explaining curriculum implementation. This could be likened to a study by Busaka et al. (2021) on Mathematics teachers' conceptual understanding of soft skills in secondary schools in Zambia, Mazabuka district who reported that the majority of mathematics teachers did not possess enough conceptual understanding of soft skills, and most of them were not aware of the methods and assessment strategies that incorporate soft skills.

5.3.2 Teaching strategies

The study revealed that teachers from both schools were aware of active teaching pedagogies that teachers can use to transmit and promote 21st Century Skills in the learners. This was vivid through one of the responses given by the teacher when asked about the teaching strategies that are expected from the teachers with regards to the 2013 curriculum. The teacher mentioned that he had a view that if learners are not involved during teaching and learning process, it may be difficult for them to acquire the skills. This goes to show that teachers should use methods that are learner centered so that learners are actively involved and always at the center of all classroom activities.

The above finding is in line with Sulaiman and Ismail, (2020) who argued that, 21st Century Skills implementation mechanisms need to be refined and applied by teachers to improve their competence as this may cultivate positive and massive impact on the teaching and learning process. This is premised on the fact that Teachers' ability to use 21st Century Skills-based teaching has successfully increased learner motivation and engagement in developing these skills (Sulaiman and Ismail, 2020). Further, this is supported by the view that the way teachers implement teaching process affects the outcomes of 21st learning (Langworthy, 2013 ; Rusdin, 2018). However, despite the teachers acknowledging the need to

employ active pedagogies during teaching and learning of mathematics, this was rarely practiced among the teachers interviewed and observed during lesson observations. This can be likened to a study done by Blom et al., (2017) in Botswana, Lesotho and Zambia, where it was established that mathematics teachers were equipped with skills to develop and assess soft skills. However, there was no indication of mathematics teachers putting great effort in integrating soft skills as tools for developing learners understanding of the subject.

5.3.3 Teacher Awareness of the general outcomes of teaching mensuration

Teacher Awareness of the general outcomes of teaching mensuration is crucial in the 21st century mathematics classroom as it helps in designing effective lesson plans. With the knowledge of the general objectives of the topic mensuration, teachers will be well able to incorporate them into their teaching strategies to ensure that learners develop a strong foundation in mensuration and are able to apply these concepts in their future studies and careers. However, during the semi structured interviews about the general outcomes of teaching the topic mensuration, based on information given by the respondents, this study established that both teachers were aware of the learning outcomes and as such their lessons were structured accordingly. For instance, one of the teachers stated that the learning outcomes of the topic mensuration would benefit the learners in terms of the careers they want to take up and examples include engineering as well as manufacturing companies. Similarly, the other teacher stated that there are many benefits and the outcomes will be in other areas of life for example in tertiary institutions. The P21 skills framework emphasizes the integration of 21st Century Skills into mathematics education, aligning with the study's focus on teaching mensuration. It highlights the importance of creating a curriculum that is relevant and engaging for learners, while also fostering essential skills such as critical thinking and problem-solving. Incorporating 21st Century Skills into mathematics instruction, educators can enhance learners' understanding of mensuration and prepare them for success in both academic and real-world contexts (Partnership for 21st Century Skills, 2008).

5.3.4 Learner-centered teaching style

In the two semi-structured interviews, both teachers emphasized on their teaching style being learner centered. And one of the teachers stated that learners should learn by guided discovery distinguished by the Teacher asking learners questions that elicit critical thinking as well as problem solving in them. The

teacher further said that he capitalizes on what learners know and direct them towards understanding new mathematical concepts. The other teacher said if learners are not involved, they will not acquire the skills.

This reveals that teachers use constructivism which is in alignment with learner acquisition of 21st Century Skills. This advocacy is supported by a study conducted by Unodiaku (2022) to determine the efficacy of the constructivist's teaching method (CTM) on teaching proof of mensuration theorem. The findings of the study clearly demonstrated that CTM is effective in enhancing learners' achievement and interest in mathematics learning, especially in proving mensuration theorems. This shows that CTM is responsible for such enhanced increase in performance of the learners and their interest and hence through CTM learners can acquire the 21st Century Skills. Similarly, a case study done by Phiri & Jumbe (2020), on promoting learner engagement in soft skills practices with Science News Media in Physics Education, established that learner engagement levels in soft skills practices were higher in classes where Science News Media (SNM) was integrated during the physics lessons than those in which it wasn't. It also established that SNM increased learners' awareness and interest to participate in soft skills practices during physics education. Finally, it established that learner engagement levels in soft skills practices were generally higher during debate and simulation than during lectures irrespective of the classes. The study's findings highlight the benefits of employing varied instructional approaches, including the integration of SNM and interactive activities. Similarly, when teaching mensuration, employing a range of instructional strategies, such as problem-based learning, hands-on experiments, and technology integration, can provide learners with different avenues to explore and apply their knowledge, enhancing engagement and understanding.

However, the current study found that teaching and learning in one of the two classes did not depict the learner centered style of teaching. In one of the classroom observations with Teacher B, traditional teaching methods were practiced to a larger extent and was characterized by the teacher giving explanations, examples and exercises with learners being passive learners. According to Wiggins (1989) the learner-centered approach enables teachers to evaluate learners according to criteria that are crucial for actual performance for their future. In addition, in some of the lessons, it was observed that the teacher to a larger extent used teacher exposition in which the teacher explained to the learners what is required to find the volume of a frustum of a cone by writing two formulae and drawing the frustum on the board. In this point of view, the learners are able to compare different ways of approaching traditional mathematical problems but will not be able to explain why they are using that particular formula.

Consequently, this does not give learners an opportunity to interact with the subject matter thereby inhibiting their creative and critical thinking skills. In addition, this does not steer an interactive classroom as learners assume learning to be passive thereby contradicting the principles of a 21st century mathematics classroom. Further on, learners during classroom tasks were evaluated based on their ability to memorize skills which is typical of assessment in the traditional style. Similarly, a qualitative study by Blom et al., (2017) in Botswana, Lesotho and Zambia which consisted of classroom observation using the instructional rounds approach found that pedagogy did not foster critical thinking. Therefore, teachers should be intentional about which skills they choose to emphasize and ensure that they are aligned with the learning goals for a particular mathematics topic or concept.

5.3.5 Teachers' knowledge on integration of technology (technical know-how)

Based on the responses obtained through an interview, the study found that teachers had no knowledge on integration of technology as they mentioned that there not sure on how to go about it unless consulting computer lab custodian. The aforementioned response highlights the need for better communication and coordination between teachers and relevant authorities responsible for technology resources in the school. Additionally, it underscores the importance of addressing teachers' professional development needs to ensure they have the technical know-how and pedagogical understanding to effectively integrate technology and create engaging learning experiences for learners in a 21st century classroom. However, the findings give an impression that despite teachers not having a technical know-how on the integration of technology in the teaching and learning of mathematics, they were aware of the benefits associated with the use of technology. They mentioned that learners would really appreciate the use of technology except that the most teachers lack technical know-how and have not undergone any form of training in readiness to teach in a 21st century classroom. Rusdin (2018) also found that despite teachers' readiness in implementing 21st century learning, more improvement was needed as a way of optimizing the learning outcomes. One of the teacher's statement about the lack of technical know-how and training points to the need for professional development opportunities for teachers. In order to effectively leverage technology in the classroom, teachers require training and support that enhances their technological skills and pedagogical knowledge. Therefore, providing ongoing professional development programs can help equip teachers with the necessary tools and strategies to create a 21st century classroom that fosters digital literacy and meaningful integration of technology.

5.3.6 Teacher knowledge on collaborative tasks

The study found that both teachers had knowledge on collaborative learning. This was vivid when one teacher mentioned that he believes in team work and cooperative learning as this can help learners to share ideas with each other and also help those who are lagging behind. The study also found that collaborative learning if well harnessed is a powerful tool as it ensures guided learning through peers. This was well elaborated by one teacher who mentioned that collaborative learning encourages the idea of learners working on their own and also working amongst themselves so that they can have confidence to explain to their friends. Further, findings give an impression that through working together, learners develop robust skills such as listening skills and being able to share knowledge with each other. This is in congruence with a study by Amirudin et al., (2015) in which the findings suggested that when learners collaborated with one another, their communication skills had improved, fostered their critical thinking and encouraged them to share ideas.

If today learners benefit from working together, they will develop a mindset of working together towards achieving a common goal knowing that it yields great ideas and consequently they will acquire not only collaborative but also communication skills. Collaborative problem solving has been identified as a particularly promising task that draws upon various social and cognitive skills, and that can be analyzed in classroom environments where skills are both measurable and teachable. Consequently, learners will be able to attain communication, creativity and critical thinking. For instance, one of the teachers created circumstances for learners to interact with each other through encouraging learners to work in groups or pairs, to express their opinions and to evaluate other learners' arguments and consequently learners progressively improved in terms of cooperation on classroom activities such as discussions as well as group and pair work.

The above findings are in tandem with Hashim et al. (2019 and Alaa, et al. (2019) who defined collaboration as working together in a team by embracing each other's talent, expertise and smart work interaction to achieve a common goal. Equally, Amirudin et al., (2015) contends that in the 21st Century Learning Design, collaboration is made up of four main elements and these include; cooperation with team members, shared responsibility, making substantive decisions together and interdependent learners' work (Amirudin et al., 2015). Therefore, 21st century teachers need to know not only how to use a practice but also when to use a practice to accomplish their goals with learners in varying contexts

5.4 Mathematics classroom teachers' practices that align with facilitation of learners' acquisition of 21st Century Skills

This section discusses the findings of the study on the second research objective which focused on determining Mathematical classroom activities that teachers engage learners in, in relation to learner acquisition of the 4Cs. The discussion is based on themes that emerged under research question two and these were: establish learners' prior knowledge; development of mathematical conceptual understanding and linkage to everyday life; limited use of technology during the teaching of mensuration; encouragement of use of several problem strategies among teacher; interactive classroom; exchange of ideas among learners; learner engagement; teaching strategy; mathematics laboratory; and questioning techniques.

5.4.1 Establish learners' prior knowledge

Teachers need learners' background information in order to modify teaching and learning activities to improve their learning. The study disclosed that both teachers began their lessons with the learners' prior knowledge. For instance, one of the teachers started the lesson on the total surface area of a cone by building on the prerequisite knowledge of the learners on the area and circumference of a circle. While during document analysis, it was erected that both teachers included prerequisite learner knowledge required for each lesson. For example, one of the teachers, on the volume and surface area of the cone included in the lesson plan on finding the area and circumference of a circle. This makes learners realize that mathematics topics and concepts are not isolated from one another. Hence learners are able to appreciate mathematics as they are able to link mathematics concepts which are useful in problem solving. According to constructivists and cognitive perspectives, learners construct new knowledge about ideas or objects that are connected to new information (Rach & Ufer, 2020).

Further, in alignment with a study done by Unodiaku (2022) in a quest to determine the efficacy of the constructivist's teaching method (CTM) on teaching proof of mensuration theorem: a solution for senior secondary school learners' interest and achievement. The findings of the study vividly demonstrated that CTM is effective in enhancing learners' achievement and interest in mathematics learning, especially in proving mensuration theorems. These recorded significant mean differences in achievement and interest of the learners after they were exposed to the treatment showing that CTM is responsible for such enhanced increase in performance of the learners and their interest. This reveals that the constructivist teaching method (CTM) emphasizes the active involvement of learners in constructing their own

knowledge through meaningful experiences and interactions. In the context of acquiring 21st Century Skills, CTM leverages learners' prior knowledge to foster their development.

Learners look for patterns by discovering fresh insights that suggest creative shortcuts or simplifying frames of reference. They are able to make generalizations from patterns they observe in repeated calculations and come to understand that mathematics is a creative endeavor that builds on previous knowledge. Consequently, this instills the skill of creativity in the learners. Many studies have found that prior knowledge strongly influences meaningful learning. Generally, the constructivist teaching method utilizes learners' prior knowledge as a foundation for acquiring 21st Century Skills. By acknowledging and building upon their existing understanding, CTM promotes critical thinking, communication, collaboration, and creativity. This learner-centered approach empowers learners to actively construct knowledge and develop the skills necessary to thrive in the 21st-century world.

5.4.2 Development of mathematical conceptual understanding and linkage to everyday life

During the lesson observations, the study revealed that learners made sense of applied mathematical problems through analysis and synthesis of evidence as they were able to give examples outside the classroom setup. In line with an ideal 21st century classroom, the teacher connects material to learners' real-world experiences by systematically using material and examples from the learners' daily life to illustrate the subject content and learners are invited to give their own examples. This does not only support learners to develop creativity and critical thinking skills but also promotes active learning and enables the learners to develop metacognitive skills.

In Zambia, a close investigation of the secondary school mathematics curriculum depicts that there is no academic year that learners do not learn the topic mensuration. This highlights the need to teach mensuration using real life contexts and goes a long way to indicate how salient the concept of mensuration is to both the individual learner and the society. In Boaler's (2002) study on experiencing school mathematics which focused on traditional and reform approaches to teaching and their impact on learner learning, learners who were taught in a traditional manner viewed mathematics as a collection of procedures yet the learners who were taught in a context viewed mathematics as an active and inquiry-based discipline. However, Kolawale and Oluwatayo (2004) in a study on Mathematics for everyday living, an implication for secondary schools asserted that the knowledge of mathematical topics and concepts with the corresponding knowledge of their application to real life situations appears to be

deteriorating. Seidman et al. (2018), UNESCO (2016) and Wolf et al. (2018) emphasized that the challenge in bringing about the desired improvements in education lies in the lack of context-specific understanding of teaching practices. Setting mathematical problems in a context helps learners to see the application of mathematics (Anthony & Walshaw, 2007; Reys, Reys, & Reys, 2013).

5.4.3 Limited use of technology during the teaching of mensuration

During lesson observations, the scientific calculator is the only form of technology that was evidently used by the learners when finding values such as the total surface area and volumes of both 2 and 3 Dimension objects respectively. This can be attributed to teachers' lack of knowledge on how to integrate technology in the teaching and learning of mensuration. The study further revealed during document analysis that the curriculum had no inclusion of how technology can be incorporated in the teaching and learning of mensuration in the mathematics classroom. These findings can be likened to a study done in Kenya by Mbako (2014) in which the study revealed that the Kenyan education system was not technology enabled. The curriculum was yet to incorporate Information Technology (IT) assessment to contribute positively towards the development of 21st century learning skills. It was also found that as to whether integration of technology enhances learners' development of 21st Century Skills, was too early to tell. This as well mean that curriculum as it is structured, is yet to adopt to address 21st Century Skills. In a quest to address the aforementioned findings, Mbako (2014) recommended that government should give priority to technology and how it can be adopted to enhance 21st Century Skills. Equally this applies to the Zambian government.

In a study by Ramaila and Molwele (2022), technology integration was largely perceived to create exciting teaching and learning environment which fosters the enhancement of academic achievement and motivation of learners. This study depicts an idea that coherent development of skills and competencies requires adoption of innovative pedagogical strategies. In espousal, a study by Bruce and Levin (1997) found strong evidence that educational technology complements what a great teacher does naturally, extending their reach and broadening their learners' experience beyond the classroom. In this regard, technology enhances learner acquisition of the 21st Century Skills. This calls for teachers are to adopt to modern approaches that incorporate 21st Century Skills. However, the challenges that Mbako (2014) alluded to in technology integration in teaching and learning impede the effective teaching of mensuration which in turn affects learner acquisition of the 21st Century Skills.

5.4.4 Encouragement of use of several problem-solving strategies among the teachers

The National Mathematics Advisory Panel (2008) report asserts that the best learning happens when learners learn the basic rules and procedures of arithmetic at the same time that they learn how to think and solve problems. For instance, during one of the lesson observations, the study established that both of the teachers illustrated the use of two methods 1 and 2 when finding the volume of the frustum of a cone. However, one of the two teachers emphasized on the use of one of the formulae while saying that it's easier and faster, do not use both methods. Therefore, it can be argued that learners could demonstrate their depth of understanding mensuration when they use more than one formula to explain and express their thinking about a solution to a problem.

In this study it was demonstrated by one of the teachers, in their lesson on finding the volume of the frustum of a cone, who modeled different problem strategies during the lesson and explained the thinking process behind each strategy. He also provided opportunities for practice to the learners by giving them a class exercise and homework where they could use both methods to find the volume of a frustum of a cone. Therefore, encouraging the use of several problem-solving strategies in the teaching and learning of mensuration can greatly benefit learners in terms of acquiring high order skills which include creativity, critical thinking as well as problem-solving skills. Thus, teachers can encourage the use of these strategies by modeling teaching strategies as well as provide opportunities for practice. This is in alignment with the 21st century classroom where the teacher selects a rich problem as a mathematics scenario that can be solved in multiple ways using multiple mathematical connections that can link the application of skills to real life. Showing learners how to solve a problem before giving them an opportunity is a compromise against active learning. The 21st century education requires that learners ought to be able to organize and analyze information.

5.4.5 Interactive classroom

Teacher A during the lessons provided the necessary guidance by going round while learners do the work in pairs. Learners during the discussion assume shared discussion and also assume shared responsibility for the work given. In addition, the teacher gives learners an opportunity to present their findings and also encourages various problem-solving strategies for teaching a knowledge point which was noticeable through the two formulas for finding the volume of the frustum of a cone as the Teacher Allowed the learners to use the two formulae. Bonwell & Eison (1991); Coulshed (1993); Felder & Brent (2003)

contend that one important component of the active learning model that distinguishes it from other learning models is an emphasis on experience rather than merely listening as a means of acquiring knowledge. In congruence with the aforementioned authors, Astin (1985 pp. 133-34) stated that "Learner involvement refers to the amount of physical and psychological energy that the learner devotes to the academic experience." This perspective aligns seamlessly with the evolution of 21st-century education, highlighting the paramount importance of active learning. In this educational paradigm, the emphasis on experiential engagement and the level of learner involvement, as described by these authors, mirrors the contemporary need for learners to acquire knowledge and skills that are not only academically rigorous but also practical and applicable in real-world contexts.

The teacher involved the learners in coming up with the formula for finding the volume of a frustum of a cone considering that they had prerequisite knowledge on the volume of a cone, similarity and congruence as well as knowledge of ratio and proportion. The teaching strategy depicted constructivism as learners made new information meaningful in relation to their prior knowledge and experiences. This steered a very interactive class as learners were actively involved in the learning and were able to articulate their mathematical thoughts and ideas. In addition, they were also able to argue reasonably while trying to come up with the formula. Learners are more likely to use and apply a formula with confidence if they can see how it links with the properties of the shape and stimulates critical thinking in the learner.

5.4.6 Exchange of ideas among learners

From the lesson's observations, it was evident that learners articulated their mathematical thoughts and ideas both orally and in writing. For instance, when learners were asked to work in pairs. This simply means that the learners are able analyze and construct viable arguments. It was evident that during the classroom discussion learners were able articulate thoughts and ideas using oral communication skills when asked to work in pairs. This fosters not only critical thinking but also learner acquisition of collaboration and communication. This can be likened to a study carried out by Amirudin et al., (2015) which investigated the effectiveness of an assessment task in enhancing the learners' understanding in mathematics through collaboration on the topic Mensuration. The findings suggested that when learners collaborated with one another, their communication skills had improved, fostered their critical thinking and encouraged them to share ideas. Thereby encouraging learner acquisition of 21st Century Skills.

5.4.7 Learner engagement

This study found that both classes were characterized by learner engagement practices. For instance, in one of the classrooms, the teacher first drew a full cone and then drew a cut cone and asked the learners to come up with the definition of a frustum. In consonance with Sullivan and McDonough (2007) who stipulated that teachers can find ways to encourage learner engagement and confidence in learning mathematics. This can be achieved by implementing meaningful activities embedded in real-life contexts (Kacerja, 2012). This is in alignment with the stipulation of Kim et al., (2019) that the teacher can provide a gradual framework to help learners understand and learn the subject matter; this process is known as scaffolding. Scaffolding can work in a lot of ways both by building on a base concept or by breaking down a concept into smaller parts. In either case, the teacher leads the learner through to a more complex concept by providing prompts, hints, and assistance. In consonance with the P21 framework, a teacher is obliged to work with learners in creating a learning environment that promotes acquisition of 21st Century Skills by ensuring a classroom community that encourages respecting other learners' ideas in order for mathematical debate to be productive and consequently, learner engagement throughout the teaching and learning process encourages learners to take ownership of their learning.

5.4.8 Teaching strategy

This study revealed that one of the respondents mostly emphasized classroom discussions and pair work throughout his lessons. Consequently, as the lessons progressed, the learners in this classroom were able to work effectively by sharing and critiquing each other's ideas. The findings of a research carried out by Salehudin et al. (2015) proved that teaching strategy and approach play important part in drawing learners' interest towards a subject in this case mathematics and substantially changes their perception about the subject regarding the difficulties (Salehudin et al., 2015). Similarly, Azmi & Nurzatulshima (2017) propounded that knowledge should be delivered integratedly with learners' learning activities. This vividly points out to the teaching strategy that the teacher employs in the classroom. In the 21st century, there is need for the teachers to use a variety of techniques such as brainstorming, role-play, games as well as other learner-centered learning activities that are appropriately planned with contents and skills to be achieved during the learning session. Therefore, it is the responsibility of the teachers to take initiative in keeping learners interested and motivated by applying various meaningful techniques and approaches in teaching and learning (Iberahim, Mahamod & Mohamad, 2017). This requires that teachers focus on

teaching and learning methods that change learners' role to be active learners who are able to acquire higher-order thinking skills such as: critical thinking, collaboration, creativity, communication, and innovation. Moreover, educators argue that critical thinking and problem solving are the new basis of learning in the 21st century because applying them enhances motivation and improves learning outcomes (Trilling & Fadel, 2009). It is on this basis that effective teaching approaches are considered to play a crucial role in increasing learners' ability to master knowledge and skills they require. At this instant, the creativity skill becomes an essential element that empowers teachers' capability to use in order to generate a variety of idea techniques as well as develop and communicate new ideas in effective ways.

5.4.9 Mathematics laboratory

Mathematics laboratory is a place where learners can explore mathematical objects, shapes and symbols to learn and verify mathematical facts and theorems through a variety of activities using different materials. These activities may be carried out by both the teachers and the learners to explore, learn, stimulate interest and develop favorable attitude forwards mathematics (Sreedharal, 2008). A mathematics laboratory provides a conducive environment for learners to explore real-life scenarios and apply mensuration concepts to practical situations. By using mathematical tools and materials in a laboratory setting, learners can analyze and solve problems that mirror real-world contexts, enhancing their understanding and relevance of mensuration. The response from interview revealed that regardless of the school being a national STEM school it had no mathematics laboratory in place and the solids that were used for mensuration lessons are stored in the mathematics department. He went on to say that learners would appreciate the topic mensuration more if they are taken to a mathematics laboratory where they can interact with solids as well as on computers and hence from there learners can be given real-life scenarios as this will enable them to relate from the abstract world to the physical world.

However, a study by Charles-ogan et al., (2014) which investigated the possible effect of mathematics laboratory in enhancing learners' conception of mensuration in senior secondary school mathematics using demonstration and collaborative approaches in Nigeria established that the mathematics laboratory using demonstration and collaborative approaches impacted significantly on learner comprehension of the concept of mensuration. Concomitantly, a study done by Olatunde (2010) on the adequacy of resource materials (Mathematics laboratory) and learners mathematics achievement of senior secondary schools in South Western, Nigeria revealed that the use of Mathematics Laboratory as a Pedagogical approach in teaching and identifying learners' difficulties and misconceptions in mensuration has been effective.

Equally, Nwoke and Nnaji (2011) illustrated that the use of Mathematics Laboratory was more effective than the lecture method in teaching and learning mathematics with respect to learners' achievement. The mathematics laboratory provides an ideal 21st century learning environment that allows the learners to think, discuss with each other and the Teacher and assimilate the concepts in a more effective manner. It enables the teachers to demonstrate, explain and reinforce abstract mathematical ideas by using concrete models, charts, graphs as well as pictures. It provides an enabling environment for learners' hands on activities as this does not only improve learner performance but also learner acquisition of the 4Cs.

One of the teachers mentioned the presence of computer labs in the school, but the lack of a mathematics laboratory means that learners cannot fully leverage technology for interactive learning experiences. Technology, such as computer simulations and educational software, can provide visual representations, virtual manipulatives, and interactive exercises that enhance learners' understanding of mensuration concepts. Therefore, integrating technology in a mathematics laboratory setting would enable learners to explore and apply mensuration concepts in a dynamic and engaging manner.

5.4.10 Questioning techniques

Sullivan and Clarke (1991) suggest the use of good questions" as they call them. They define them as having three features: they require more than recall, they are open-ended, and they promote active learning. Higher-order thinking and real-world problem-solving are two important elements that make up the substance of authentic assessment (Koh, Tan, & Ng, 2011, p. 139). For instance, in one of the lesson observations, the Teacher asked the learners why there was no pi (π) in the formula for the volume of a frustum of a pyramid and the learners responded that there was no circle on the pyramid which fosters critical thinking in the learner as they are able to reason and actively participate as opposed to being passive learners. This shows that learners were able to develop new and valuable ideas using existing knowledge and resources which entails creativity. The Teacher also asked learners to reflect on the solutions or answers they give to problems or questions. In addition, learners are able to apply the connections between information and arguments in order to support a perspective which elicits critical thinking.

In another instance during lesson observation in one of the classrooms, the teacher probed the learners on finding the volume of the frustum of a cone. This demonstrates that the teacher focused on fostering critical

thinking in learners. It was observed that the teacher motivated the learners to think about the advantages and disadvantages of certain approaches.

5.5 Ways in which Classroom based formative assessments is administered by mathematics teachers in alignment with 21st Century Skills

This section discusses the findings of the study on the third research objective which focused on exploring ways in which Classroom based formative assessments is administered by mathematics teachers in alignment with 21st Century Skills. The discussion is based on themes that emerged and these were: the curriculum lacked clearly defined rubrics on performance assessment; teachers had limited knowledge on the forms of 4Cs assessment; lack of practical experiences in the classroom; lack of mathematical challenging tasks; teacher feedback to the learners and assessment and teacher feedback to the learners and assessment. The researcher collected data from document analysis, lesson observations and semi-structured interviews.

5.5.1 Clearly defined rubrics on performance assessment in the curriculum

During document analysis it was revealed that despite the emphasis on the 4Cs as key competences in the Zambian 2013 curriculum framework, this has not been translated into clearly defined implementation plans, descriptions of appropriate teaching strategies, or development of well-designed assessment tools. However, the 2013 curriculum, emphasizes the use of clearly defined rubrics (or criteria) to facilitate a fair and consistent assessment of learner's work. This refers to learning progression, a carefully sequenced set of building blocks that learners must master en route to mastering a more distant curricular aim which are 21st Century Skills in this case. These building blocks consist of subskills and bodies of enabling knowledge (Popham, 2007). In line with a study by Care et al., (2018) which revealed that communication, creativity, critical thinking, and problem solving were the four most frequently identified skills within national policy documents of the 152 countries which included Zambia. A study in 152 countries found that specific skills embedded within their curricular documents, but in 58 (38%) countries including Zambia did not show evidence of progressions of skills. This could be ascribed to the lack of clearly defined rubrics in the 2013 Zambian curriculum framework.

Rubrics provide learners with clear expectations and criteria for success. When learners understand the assessment criteria, they can better self-assess their work, set goals for improvement, and engage in

reflective practices. Rubrics also facilitate constructive feedback, as teachers can provide specific feedback based on the rubric's criteria, highlighting areas for improvement and recognizing strengths. The inclusion of clearly defined rubrics in the curriculum can contribute to a more effective and meaningful assessment process. Rubrics provide a shared understanding among teachers, learners, and other stakeholders about the expectations and standards of performance. They promote transparency, consistency, and fairness in assessment, allowing for a more accurate and comprehensive evaluation of learners' progress in developing the 4Cs.

However, the lack of clearly defined rubrics on performance assessment puts teachers at a disadvantage especially the new teachers and compromises the whole purpose of assessment. Frey, Schmitt, and Allen (2012) posited that a meaningful, real-world task or problem is characteristic of performance-based assessment. Without these learning outcomes being specified clearly in curricular documents, as well as more broadly at education policy level, there can be no monitoring of learner progress in skills acquisition. Therefore, the lack of evidence associated with the effective delivery of 21st Century Skills also point towards the need to develop clear models for mapping progression in the acquisition of 21st Century Skills, and based on that, to gather evidence on the impact of the range of system-wide interventions associated with their delivery. Concisely, all assessment requires a framework if assessment is to provide meaningful information linked to curricular goals (Care et al, 2018).

In congruence with the later study, Chileshe et al., (2021) conducted a study in Kenya, Rwanda and Zambia on comparative review of literature on the integration of soft skills in Mathematics which reflected that the revised curriculum frameworks revealed that there was lack of adequate literature on the integration and assessment of soft skills which points to the fact that these skills may not be integrated in the teaching and learning of Mathematics. This has serious implications for both the Teacher and the learner in the mathematics classroom where curriculum implementation occurs which may deprive learners of fully acquiring the 4Cs. Similarly, in a study done by Blom et al., (2017) in Botswana, Lesotho and Zambia, no evidence was found from the literature reviewed of the three countries on ascertaining the facts that soft skills integration and assessment are prioritized.

Assessment of 21st Century Skills may be more useful especially if skills are aligned at classroom level with national learning goals. In this regard, Koh, Tan, and Ng (2011) asserted that performance assessments are intended to measure learners' knowledge and skills at deeper levels than traditional

assessments and tend to prompt learners to solve authentic or real-world problems. Equally, Newmann et al. (1996) claims that authentic intellectual work engages learners much more than routine practices of gathering facts and applying procedures. The curriculum must be aligned to produce a support system that concomitantly produces 21st century outcomes for today's learners.

5.5.2 Information on assessment of 21st Century Skills by teachers

The semi-structured interviews separately conducted with each teacher revealed that both mathematics teachers had knowledge on 21st Century Skills, and both of them were aware of some of the methods however they lacked assessment strategies that incorporate the 4Cs as well as implementation of some of the 4Cs which include creativity and critical thinking. Teachers had very little information about assessment of the 4Cs as both of them referred to exercises and occasional tests as the only form of assessment. Both teachers' responses on assessment can be attributed to them not being familiar with the assessment techniques that could be used to assess the 4Cs. Further on, both teachers had difficulties in explaining what curriculum implementation is. This could be likened to a study by Busaka et al. (2021) on Mathematics teachers' conceptual understanding of soft skills in secondary schools in Zambia, Mazabuka district who reported that the majority of mathematics teachers did not possess enough conceptual understanding of soft skills, and most of them were not aware of the methods and assessment strategies that incorporate soft skills. However rather than evaluating learners through a method of tests and exercises for example, learners' performances need to be assessed through different methods in the 21st century mathematics classroom. Assessment ought not to be only concerned with concept mastery but also with process skills proficiency.

A study by the Asia-Pacific Education Research Institutes Network (2015) on the use of data from 21st Century Skills assessments further revealed that current assessment practices reflect uneven implementation and embedding of 21st Century Skills in the teaching and learning process. Similarly, (PISA, 2003b) stipulated that rather than measuring achievement in terms of specific curricula, with its focus on reading, mathematical and scientific "literacy", PISA emphasizes the mastery of processes, the understanding of concepts, and the ability to function in different situations in each domain, rather than the possession of specific knowledge. This highlights that there may be lack of technical understanding of how to integrate assessment activities and use the information (Care & Luo, 2016). However, the 21st century education assessment in the mathematics classroom should be mediated by a method of teaching

that promotes critical thinking, communication, collaboration and creativity which are part of the 4Cs, which assists teachers to teach and assess learners' understanding and make connections between concepts explicitly. Therefore, there is need for a major teacher training and professional development to build the capacity of teachers to teach and assess 21st Century Skills (Saavedra & Opfer, 2012).

5.5.3 Practical experiences in the classroom

The study established that in spite of the stress on Outcome Based Education (OBE) in the Zambian 2013 curriculum framework, learners in both classes were not given any form of hands-on experiences during the teaching and learning of mensuration. On the contrary, the 21st Century Skills framework focuses on providing opportunities for applying 21st Century Skills across content areas which includes mathematics and for a competency-based approach to learning.

In a study done by Charles-ogan et al., (2014) which investigated the possible effect of mathematics laboratory in enhancing learners' conception of mensuration in senior secondary school mathematics using demonstration and collaborative approaches in Rivers State. The findings established that learners who were taught using demonstration with mathematics laboratory approach outperformed all their counterparts in terms of understanding of concepts of mensuration. Hands-on experiences enable learners to develop a deeper understanding of the subject matter. When learners actively manipulate objects, explore geometric shapes, or participate in measurement activities, they can visualize abstract concepts and make connections between theory and practice. This active engagement enhances their comprehension and helps them retain the information for a longer period. Hands-on learning also promotes the development of problem-solving skills. Through engagement in practical activities, learners encounter challenges and have to think critically and creatively to find solutions. They learn to analyze problems, apply mathematical concepts, and develop logical reasoning skills. This problem-solving mindset is transferrable to other areas of learning and life. This can be likened to a case study done by Phiri & Jumbe (2020), on promoting learner engagement in soft skills practices with Science News Media in physics education, a case study of Chiwala Technical Secondary School in Zambia (2020). The study established that learner engagement levels in soft skills or 21st Century Skills practices were higher in classes where Science News Media (SNM) was integrated during the physics lessons than those in which it was not. It also established that SNM increased learners' awareness and interest to participate in 21st Century Skills practices during physics education. Finally, it established that learner engagement levels in 21st century

practices were generally higher during debate and simulation than during lectures irrespective of the classes. This suggests that incorporating real-world examples, multimedia resources, or other forms of interactive content can enhance learner engagement. In the context of teaching mensuration, introducing practical experiences or real-life applications of the concepts can potentially increase learner engagement and interest. The study noted that learner engagement levels were generally higher during debate and simulation activities compared to traditional lectures. This implies that interactive and participatory learning strategies promote higher engagement levels among learners. Therefore, in the context of teaching mensuration, incorporating hands-on activities, group discussions, and problem-solving tasks can provide learners with practical experiences and opportunities for active engagement.

Similarly, a study done by Blom et al., (2017) in Botswana, Lesotho and Zambia, found that pedagogy did not foster critical thinking. In addition, learners' teamwork, collaboration and active learning were generally absent and instruction in all classrooms was generally teacher centered. Further on, mathematics teachers are equipped with skills to develop and assess soft skills. However, there was no indication of Mathematics teachers putting great effort in integrating soft skills as tools for developing learners understanding of the subject.

Therefore, the lack of practical experiences in a 21st century mathematics classroom when teaching mensuration may hinder learners' ability to connect abstract mathematical concepts with real-life applications. By incorporating practical experiences, such as measuring objects or calculating real-world quantities, teachers can bridge the gap between theory and practice, enabling learners to better understand the relevance and utility of mensuration. In summary, the lack of practical experiences in a 21st century classroom when teaching mensuration can be addressed by incorporating interactive and real-life applications of the concepts. Integrating practical experiences, such as hands-on activities, real-world problem-solving tasks, and technology-based resources, can increase learner engagement, awareness, and interest in 21st Century Skills practices. By adopting varied instructional approaches, teachers can create a dynamic learning environment that fosters deeper understanding and application of mensuration concepts in real-life contexts.

5.5.4 Mathematical challenging tasks

Walls (2005) defines mathematical tasks as the kinds of activity that teachers of mathematics assign or set their learners" (p. 751) and they take a variety of forms, length, and complexity. Mathematical Challenge

describes the challenges offered to learners to provoke mathematical thinking and activity; this includes tasks set, questions posed and emphasis on metacognitive processing (Jaworski, 1994). Sometimes they are just questions posed verbally and others are worksheets or content of the learners‟ textbooks. They could be open-ended questions or real-life situations that should be explored from the mathematical point of view.

Findings of the study give an impression that learners were not given enough challenging tasks that when worked on can elicit learner acquisition of the 4Cs. The study found that classroom based formative assessments administered by mathematics teachers were not practical and challenging due to the fact that in most cases teachers employed expository teaching were learners were passive in the teaching and learning process. During the lesson observations, it was evident in both classes that learners were not given challenging enough tasks that when worked on can foster learner acquisition of the 21st Century Skills. In usual cases learners were expected to use the given formulas to find the values of volumes and total surface area of 3D solids. For instance, during one of the lessons, the teacher wrote down the formulas and gave examples on how to use the formulas given to find the volume, the area and total surface area of a cone. This reveals that teachers use performative tasks rather than knowledge building tasks in the mathematics classrooms. Performative tasks refer to those that entail the use of lower order thinking skills like recall and direct application of knowledge. This implies that learners are unlikely to be encouraged to engage in learning activities that ensure the development of mental processes and hence foster learner acquisition of the 21st Century Skills. The Lack of challenging tasks in the mathematics classroom may also be attributed to the teachers' lack of knowledge to effectively use challenging tasks in the classroom consequently teachers are often reluctant to use them.

The above findings do not resonate well with the study by Zivkovil (2016) who emphasized the need for critical thinking for learners. This is premised on the fact that Mathematics is a discipline grounded in critical thinking, it is considered to be one of the fundamental subjects to sharpen and augment critical thinking skills of learners. This goes to show that in order to solve a problem, learners need to initially identify the problem and then analyze it to examine whether or not it can be solved. This could be accompanied by them looking at various possibilities to solve a particular problem. This could be achieved by selecting the most effective and efficient way of overcoming the problem (Hashim et al., 2019).

The findings of the study underscore the importance of aligning classroom practices with the theoretical framework of 21st-century education, particularly in terms of assessment, curriculum and instruction, and

learning environments. By addressing the identified gaps and enhancing teacher practices in these areas, educational systems can better support the development of 21st Century Skills among learners. They P21 Framework emphasizes the need for improved feedback and assessment practices in mathematics education to support the development of 21st Century Skills. Teachers often rely on limited forms of assessment, overlooking the importance of explicit feedback and mind-provoking questions. This highlights a gap in integrating the 21st century curriculum and instruction framework, which emphasizes the need for balanced assessments and the promotion of critical thinking. To address these challenges, there is a need to enhance teacher practices and create learning environments that prioritize the teaching and learning of 21st Century Skills.

5.5.5 Teacher feedback to the learners and assessment

Feedback is an important aspect of the overall teaching and learning process in 21st century education. Feedback of performance has been demonstrated to be a powerful tool in improving practice in a breadth arena from individual behavior to organizational performance (Butler and Winne, 1995). Based on the lesson observations conducted and face to face interaction with teachers, the study found that teachers could go round to check the learners work after giving them a task and instructed them to work in pairs. For instance, in certain instances during the lesson observation on the total surface area of a cone, one of the teachers did not give feedback to the learners and there was no prior example on the slant height hence these steered misunderstandings on certain mathematics concepts. However, assessment and evaluation of 21st Century Skills requires that the teacher gives explicit, detailed and constructive feedback; the teacher makes explicitly clear why an answer is correct or not and; the teacher provides his/her feedback on the answers given by the learners even in the books of the learners as this gives guidance to the learners understanding of certain mathematical concepts. Therefore, feedback that involves a focus on the detailed content of what is being learnt has a central function of formative assessment.

Findings gives an impression that teachers had limited forms of assessment during the teaching of mathematics to the learners. Both teachers referred to classroom exercises as the only form of assessment given to the learners and tests which are given occasionally. On the contrary, Partnership for 21st Century Skills (2008) emphasized that limited knowledge on the forms of assessment may deny learners an opportunity to assess their levels of progression and learning difficult.

Despite limited knowledge on assessment of 4Cs, both teachers were aware that learners should be given mind provoking questions as one teacher mentioned that the questions for the learners should be designed in such a way that they are able to provoke critical thinking, abstract thought and spatial visualization in order for learners to think in a certain way. Nevertheless, the study found that this was rarely practiced in the classroom by both teachers from classes A and B. The 21st Century Skills framework puts emphasis on the use of feedback on learner performance that is embedded into everyday learning and it requires a balance of technology-enhanced, formative and summative assessments that measure learner mastery of 21st Century Skills (Sulaiman & Ismail, 2020).

5.6 Challenges from the perspective of mathematics teachers in the context of teaching for learners' acquisition of 21st Century Skills.

Throughout the study, several challenges that impede the effective teaching and learning of mathematics in the 21st century classroom were identified. These challenges encompass limited access to computers and a lack of computer training, insufficient support from school management, classroom overload with a focus on syllabi completion, inadequate teaching and learning materials, restricted time allocation for mathematics lessons, infrequent teacher training workshops on 21st Century Skills, and learners' attitudes. The discussion of these problems has shed light on the significant issues that hinder teachers from seamlessly integrating 21st Century Skills into the teaching of mensuration. This section will delve into a detailed exploration of the challenges faced by teachers during mensuration instruction, followed by the proposed solutions. These solutions, which include procuring updated teaching and learning materials, conducting regular teacher training workshops focused on 21st century education, deploying additional teachers, garnering enhanced support from school management, expanding the number of mathematics periods, and fostering motivation among both mathematics learners and educators, collectively address the multifaceted challenges faced in the pursuit of effective 21st century mathematics education.

5.6.1 Limited computers and no computer training

From the responses given during the interviews, it was eminent that both teachers lacked knowledge on integration of technology (technical know-how) in the teaching and learning of mensuration as one of the teachers said mostly, we teachers should undergo training so as to enable us to make use of such resources (computers). It was found that teachers believe that the use of media and technology can foster action in producing interactive learning and ultimately improve the quality of teaching the topic mensuration as one

of the teachers stated that Learning would be more interesting as learners will interact with graphic designs 3D and 2D objects. He went on to say meaningful learning would occur. This just shows that teachers have ideas on the importance of technology and how they can incorporate it into the teaching and learning of mathematics but not adequate to ensure effective implementation of such. Therefore, teachers feel a great need for training in the 21st Century Skills that are fundamental for developing their work in the classroom. The lack of technology teaching and learning facilities creates a less conducive environment and hence is seen as one of the pertinent challenges for teachers in implementing 21st Century Skills-based teaching.

In a study done by Sulaiman and Ismail (2020) on teacher competence and 21st Century Skills in transformation schools 2025 (TS25) the findings predicted that information and communication technology (ICT), are significant contributors to 21st Century Skills. The findings also show that the dimensions of teacher competence have the potential to help further develop the potential of teachers in line with 21st century learning (PAK-21) concepts. The latter is supported by a study done by Ramaila and Molwele (2022) which examined the role of technology integration in the development of 21st Century Skills and competencies in Life Sciences teaching and learning found that technology integration was perceived to promote the acquisition of 21st Century Skills and competencies in Life Sciences teaching and learning. In particular, the teachers indicated that technology integration facilitates the development of skills such as communication, critical thinking, collaboration, problem solving and computational thinking.

Slaouti & Barton (2007) emphasized that obstacles such as access to equipment, time pressures, lack of mentor and opportunities for apprenticeship of observation also have an impact on teachers' ability to use ICT. The study found that teachers lack basic skills in the use of ICT equipment and software which results in lack of confidence in utilizing ICT tools to impact on learning. The aforementioned challenge as alluded to by Slaouti & Barton (2007); Mbako (2014) could be the problem that mathematics teachers are facing with regards to implementing integration of technology in the classroom. The impact is that the learning environment will not enhance learner acquisition of the 21st Century Skills which is contrary to the profound purpose 21st century learning environments.

5.6.2 Lack of support from school management

The study established that there was lack of support from the school administration based on the responses from both teachers. The teachers stated that the head teacher tends to be biased (inclined to their subject) in terms of resource allocation which include teaching and learning materials, professional development as well as time allocation. One of the teachers went on to articulate that this affects the learners' attitudes towards the subject mathematics. The consequences of these issues can be far-reaching as it not only impacts teachers but also has a direct influence on learners' attitudes and perceptions of mathematics. When mathematics is not given due importance within the school environment, learners may perceive it as less significant or relevant, which can contribute to disinterest and a lack of motivation to engage with the subject. When teachers perceive a lack of support from school administration, it can demotivate them in their efforts to teach mathematics effectively. The absence of recognition and encouragement may impact their enthusiasm and dedication, ultimately affecting the quality of instruction they provide. Insufficient support for mathematics may result in a lack of resources such as textbooks, manipulatives, or technological tools needed to enhance learners' learning experiences.

Additionally, there may be limited opportunities for professional development and collaboration among mathematics teachers, hindering their ability to improve their teaching practices. Consequently, lack of support from the school management may result into negative learner attitudes; if mathematics is consistently overshadowed and undervalued, learners may develop negative attitudes towards the subject. They may perceive it as unimportant or difficult, leading to disinterest, low motivation, and decreased academic performance in mathematics. This can have long-term consequences, as mathematics skills are essential for many higher education and career pathways. However, to address these challenges, it is crucial for the school management to recognize the importance of mathematics education and provide adequate support to teachers and learners. This includes fostering a positive school culture that values mathematics, allocating resources to enhance mathematics teaching and learning, and promoting professional development opportunities for mathematics educators (Partnership for "1st Century Skills, 2008). By addressing these concerns, the school can create an environment where mathematics receives the attention it deserves, leading to improved outcomes for both teachers and learners. The lack of school management support contradicts the sole purpose 21st century learning environments that aim at human support and physical environments that will support the teaching and learning of 21st century skill outcomes.

School principals and school management are vital to the success of 21st Century Skills development, especially in the provision teaching and learning resources such as ICT infrastructure, software, books for both teachers and learners, and appropriate training opportunities to enhance teachers' competencies. This is supported by a study done by Sulaiman and Ismail (2020) on teacher competence and 21st Century Skills in transformation schools 2025 (TS25) in which the findings forecasted that school management and development are significant contributors to 21st Century Skills. In an effort to attain sustainable empowerment on the part of school councils as well as leadership, in-service training should be offered to school principals for an effective implementation of a curriculum framework and practices (Bandur et al., 2021). Therefore, addressing this challenge requires a collaborative effort between teachers and school administrators. It is crucial for administrators to recognize the importance of mathematics education and provide the necessary support and resources to foster a positive learning environment. By promoting a culture of support for mathematics, administrators can empower teachers to implement effective classroom practices, enhance learners' attitudes towards the subject, and ultimately promote a deeper appreciation and understanding of mathematics among learners.

5.6.3 Teaching and learning materials

From the responses given, it was revealed that since the implementation of the 2013 curriculum framework there has not been remarkable changes in terms of text books. One of the responses from Teacher B was a complaint on pre-requisites on the topic mensuration not being included for instance, the area and circumference of 2D shapes like a circle making it difficult not only for the learner but also teachers to connect the concepts. This poses a major challenge as books are pertinent to effective implementation of the 2013 Zambian curriculum framework. Niaz (2013) states that text books carry a very strong influence as they are a primary source of information used not only teachers but also learners in classrooms. After a curriculum has been changed, the text books will determine how the topics are explained and the depth of coverage. Howson & Kingsbury (2021) also stipulated that curriculum change involves changes to teaching materials, pedagogical values, knowledge of theory for practice, and assessment factors which contribute to having appropriate infrastructure in place for change to thrive. Quality education requires the availability and use of educational materials. However, the current situation in Zambian Secondary Schools is that educational facilities and resources are not available for effective teaching and learning. (CDC, 2013). “Access to teaching and learning material/equipment presents a continuing obstacle to quality learning in secondary schools” (ESSP, 2021 p.63). The latter statements point out that

implementation may be regarded as simple, but practice has proved that it is constrained by a number of factors such as the environment, inadequate resources, lack of information, and so on.

5.6.4 Classroom overload and emphasis on syllabi completion

Mathematics teaching is an interaction between the Teacher and the learners that leads to acquisition of desirable mathematical knowledge, ideas and skills necessary for applicability in our everyday life. During the first semi-structured interviews, one of the teachers said they are overwhelmed with classes as the number of teachers in the mathematics department is limited. Teachers being overloaded with classrooms compromises the quality of teaching and learning in the 21st century mathematics classroom as this limits the time for adequate planning of teaching and learning strategies with regards to the learners' needs and interests equally limiting learner acquisition of the 4Cs.

During lesson observation it was revealed that teachers emphasize on examinations. For instance, one of the teachers sternly told the learners that if they failed to understand a question on volume of the pyramid, 6 marks is gone from their final exams. He further insisted that these types of questions normally come. This illustrates that emphasis on the mathematics syllabi completion influences how teachers teach. Teachers are reported to face the compact curriculum and central exam issues (Rajendran, 2001) where teachers must cover the syllabus and prepare learners for examination (Rajendran, 2001; Saad, Saad & Dollah, 2012). Teachers teach to the test which promotes rote learning instead of meaningful learning which the 21st century learning solely advocates for. Hence this inhibits learner acquisition of the learning and innovation (4Cs) skills.

5.6.4 Time allocated to mathematics lessons

This study realized that the periods allocated to mathematics are less based on the responses given by both teachers. In attempts to instill each learner with 21st Century Skills, teachers face a great challenge since there are many 21st Century Skills to be instilled in limited teaching times (Yunos, 2015). The attempts to instill 21st century among learners is quite difficult as the learners have different previous knowledge, passion, motivation and learning style.

With limited time dedicated to mathematics lessons, it may be challenging for teachers to cover the entire curriculum comprehensively. This could result in important topics or concepts being rushed or skipped altogether. As a result, learners may have gaps in their understanding and knowledge of mathematical

concepts, which can hinder their progress in subsequent lessons or grades. Sparingly, just as one teacher pointed out, each learner has unique learning needs and may require additional support or attention in specific areas of mathematics. With limited time, it becomes challenging for teachers to provide individualized instruction or address the diverse needs of learners effectively. This can result in some learners falling behind or feeling frustrated due to a lack of personalized support. Further, mathematics is not only about memorizing formulas and procedures but also about developing a deep conceptual understanding and critical thinking skills. However, limited time for mathematics lessons may restrict opportunities for in-depth exploration of mathematical concepts and the development of problem-solving and reasoning skills. Consequently, learners may end up relying on rote memorization rather than developing a deep understanding of mathematical principles.

Addressing the issue of limited time allocated to mathematics lessons may require collaboration among school administrators, teachers, and relevant stakeholders to prioritize mathematics education, allocate sufficient time, and provide necessary support to ensure quality teaching and learning experiences for learners. Another solution that would prove effective is professional development and support for non-specialist teachers. In cases where the head teacher, who may not be a mathematics specialist, is responsible for allocating time to different subjects, there may be a lack of understanding or prioritization of the specific needs of mathematics education. Non-specialist teachers may benefit from additional professional development and support to enhance their knowledge and instructional strategies in mathematics, ensuring that they are equipped to provide quality mathematics education within the limited time available.

5.6.5 Learners' attitudes

The observations and responses in this study entails that the learners' attitudes negatively affect the teaching and learning process which in-turn affects learner acquisition of the 4Cs in the mathematics classroom. The most eminent learner attitudes included: late coming for lessons, laziness, not taking books for marking as well as failure to interact and express their ideas. However, learning mathematics does not only involve thinking and reasoning, it is dependent on the attitudes of the learners towards learning and mathematics (Anthony & Walshaw, 2007; Grootenboer, Lomas, & Ingram, 2008). Kele & Sharma (2014) further stated that researchers have concluded that learners' attitudes play a vital role in the learning of mathematics. A positive learner attitude enables learners to welcome new experiences and recognize the

many different kinds of learning opportunities in the mathematics classroom. Therefore, they are a crucial point in creating a conducive learning environment which facilitates effective 21st century education (Partnership for 21st Century Skills, 2008).

5.6.6 Teacher training workshops on 21st Century Skills are rarely conducted

During the second semi-structured interviews, it was found out that a teacher training workshop on implementation of the 2013 curriculum framework was done once just after its effect, and one of the teachers who was in attendance stipulated that the teacher training was inform of a 2-week workshop that was carried out in zones. These workshops were done generally and were not subject specific. However, a challenge in bringing about the desired improvements in instructional quality lies in the lack of context-specific understanding of teaching practices and meaningful ways of supporting teacher professional development (Seidman et al., 2018; UNESCO, 2016; Wolf et al., 2018). In addition, teachers who joined the teaching profession later as is the case of one of the teachers did not undergo any kind of training and the mathematics departments lacked resources on such except, they only had the syllabus for reference. The aforementioned discrepancy is something that has not been solved yet. If this phenomenon persists, it is unlikely that teachers will be able to demonstrate high self-esteem as well as ensure that learners develop the 21st Century Skills.

During the interviews, one of the teachers recommended that they should undergo training by curriculum specialists about 21st Century Skills for instance technology and how it should be implemented in the mathematics classroom in order to ensure effective curriculum implementation in the teaching of mensuration as well as other mathematics topics. This depicts that teachers feel a great need for training in the 21st Century Skills that are fundamental for developing their work in the mathematics classroom. Teacher training is cardinal to effective implementation of the intended curriculum. Consistently, Jess et al. (2016) found the need to prepare and train teachers to meet the objectives of a curriculum, the authors' focus was precisely on the curriculum-development process and the role of the educator. Jess et al. (2016) contemplated that teachers need the capacity to design developmentally appropriate learning tasks and activities that are aligned to curricular expectations. In the 21st century education, the focus of training and professional development requires an emphasis on teaching how best to interpret the curriculum so that learners' needs will be aligned with appropriate instructional practices (Jess et al., 2016).

5.6.7 Encourage the use of Outcome Based Assessment

Outcome-based assessment is an approach that focuses on evaluating the results or outcomes of learning rather than just assessing the learning process itself. Lack of knowledge and understanding on the part of the teacher limit the opportunities for learners to acquire skills and affects their ability to apply these skills continuously. Concurrently, Care (2018) p.1 contends that the components of the education system must be aligned to support the development of 21st Century Skills, and the qualitatively different structure of these skills requires some completely new approaches, both in the measurement aspect and collection of assessment data. Therefore, teachers must increase their knowledge in all aspects through the new assessment system to develop a holistic learner so that they become useful global citizens.

The study revealed that in order to mitigate the aforementioned challenges, teachers mentioned that school managements should purchase mathematics teaching and learning materials, number of periods for teaching mathematics should be increased, conduct workshops on the integration of 21st Century Skills in the mathematics classroom, more elaborate materials should be prepared, link mensuration to real life problem solving, government to deploy more mathematics teachers and there is need for management to support teachers of mathematics. These finding are evidenced by excerpts and snapshots.

5.7 Chapter Summary

This chapter discussed the findings that were presented in chapter four. It discussed the findings on Lack of adequate knowledge of 21st Century Skills among teachers, limited teaching strategies, Teacher Awareness of the outcome of teaching mensuration, teaching strategies and styles, teachers lacked knowledge on integration of technology (technical know-how), and teacher knowledge on collaborative tasks. It further discussed findings on establishment of learners' prior knowledge, exchange of ideas among learners, learner engagement, teacher feedback and assessments, development of mathematical conceptual understanding and linkage to everyday life as well as encouragement of use of several problem-solving strategies among the teachers. Discussing these aspects brought to light the importance of adhering to 21st century principles in the teaching of mensuration. The problems that the teachers encountered during the teaching of mensuration were also discussed and some of these were: Limited computers and no computer training; Lack of support from school management; classroom overload and emphasis on syllabi completion; inadequate teaching and learning materials; limited time allocated to mathematics lessons; learners' attitudes and teacher training workshops on 21st Century Skills are rarely. Discussing

these problems brought out serious issues that hinder teachers from effectively integrating 21st Century Skills in the teaching of mensuration. The solutions that they gave to the problems were also discussed and these include: purchase updated teaching and learning materials, conduct regular teacher training workshops more on 21st century education, more teachers to be deployed, improved support from the school management, increase the number of mathematics periods, and motivate learners as well as teachers of mathematics. Discussing these solutions brought about issues that various stakeholders need to put into consideration before effecting a revised curriculum. The following chapter will conclude the study and also give recommendations with respect to what was found.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Overview

This chapter contains the conclusion to summarize the overall findings of the study on Mathematics Classroom Practices in the Context of 21st Century Skills. The chapter also contains the possible recommendations emanating from the findings. The recommendations are directed to specific Ministries, institutions and the classroom. Further, the chapter highlights areas of research that may be undertaken by other interested researchers which were outside the scope of this study.

This study contributes to the body of knowledge in mathematics education by highlighting the challenges and gaps in integrating 21st Century Skills into mathematics classroom practices, particularly in the Zambian context. Through its qualitative exploration of mathematics teachers' practices and perceptions, the study sheds light on the disconnect between theoretical aspirations of 21st Century Skills and their practical implementation in the classroom. Particularly, this study emphasizes the importance of addressing teachers' awareness and understanding of 21st Century Skills beyond technology. It underscores the need for comprehensive professional development programs that equip mathematics teachers with innovative teaching strategies aligned with 21st century skill acquisition. Furthermore, the study highlights the importance of aligning classroom assessments with the development of 21st Century Skills among learners. These insights and recommendations offer valuable contributions to discussions aimed at enhancing mathematics education practices, not only in Zambia but also in other contexts facing similar challenges, ultimately preparing learners for success in the dynamic 21st century landscape.

By addressing these issues, the study provides valuable insights and recommendations for improving mathematics education practices in Zambia and potentially in other contexts facing similar challenges. It contributes to ongoing discussions and efforts to enhance the relevance and effectiveness of mathematics education in preparing learners for success in the 21st century.

6.2 Conclusion

This study investigated Mathematics Classroom Practices in the Context of 21st Century Skills. The objectives of the study where to determine what mathematics teachers know about 21st Century Skills; to

determine how mathematics teacher's classroom practices align with facilitation of learners' acquisition of 21st Century Skills; to examine ways in which classroom-based assessments as administered by mathematics teachers are aligned with 21st Century Skills and to establish the challenges from the perspective of mathematics teachers in the context of teaching for learners' acquisition of 21st Century Skills. The study took a qualitative approach which gave descriptions of what was going on in the classrooms regarding the integration of 21st Century Skills in the teaching and learning of mathematics.

In considering experiences from other countries, the integration of the 4Cs into mathematics education should be approached with a careful and objective evaluation of its applicability in the Zambian context. This study focused on mathematics teachers' classroom practices particularly in mensuration instruction among grade eleven learners in selected secondary schools in Lusaka district. It was centered on three of the five critical support systems outlined by P21: assessment of 21st Century Skills, 21st century curriculum and instruction, and 21st century learning environments. The participating teachers displayed limited understanding of 21st Century Skills, particularly in their application to teaching mensuration. They primarily associated 21st Century Skills with technology and lacked knowledge about various assessment methods beyond classroom exercises and periodic tests. While they were aware of the benefits of integrating technology into mensuration teaching, they struggled to incorporate it effectively into their lessons. Additionally, their teaching of mensuration lacked consistency and systematic implementation, despite their knowledge of learner-centered strategies recommended for 21st-century mathematics classrooms. Furthermore, the study found that although the 2013 Zambian Curriculum Framework included 21st Century Skills as core values, it lacked well-defined performance assessment rubrics and guidance on how to integrate these skills into mathematics instruction. Curriculum integration guidelines, as suggested by Ali and Maat (2019), could play a vital role in supporting teachers to frame learning around relevant issues that learners can explore and connect with in diverse ways.

Integrating 21st Century Skills (4Cs) like communication, collaboration, creativity, and critical thinking into classroom teaching is vital for preparing learners to thrive in today's rapidly changing world. These skills foster the ability to think critically, solve complex problems, and promote creativity and innovation, which are crucial for success in both businesses and organizations. In the 21st century, success is no longer solely about memorizing facts but about understanding complex concepts and using them creatively to generate new ideas, theories, and knowledge. Learners also need strong communication and collaboration skills, as emphasized by the OECD, to excel in the modern work environment. This flexible approach to

instruction, rooted in the 4Cs, acknowledges the evolving needs of learners in a changing educational and social landscape, underscoring the pivotal role of teachers as implementers in integrating these skills into mathematics education. This study draws on related literature from various parts of the world and disciplines to shed light on mathematics teachers' classroom practices in the context of 21st Century Skills.

The P21 framework from 2008 stressed the importance of developing 21st Century Skills within the context of existing school subjects. While modern education places a strong emphasis on a broader skill set, it acknowledges the significance of core academic subjects like mathematics, science, language arts, and social studies. These subjects provide learners with a foundational knowledge base. Thus, the P21 framework, endorsed by organizations like CISCO Global Education, sought to create a comprehensive framework encompassing specific skills, content knowledge, expertise, and literacy, aiming to transform learning. Foundational skills such as arithmetic, algebra, and geometry should not be neglected in the pursuit of contemporary skills. Striking a balance between these areas is vital. Effective curriculum implementation hinges on the abilities and skills of teachers, who, despite limited resources, are expected to find creative ways to achieve learning objectives. While challenges exist, including resource constraints, school management support, overloaded classrooms, syllabus completion pressures, inadequate materials, limited class time, and learners' attitudes, it remains evident that mathematics teachers' classroom practices in the context of 21st Century Skills at the selected school faced significant hurdles. Despite these challenges, 21st century education's central aim is to prepare learners for the demands and opportunities of the modern world, emphasizing a diverse range of skills and competencies essential for 21st-century success.

The paramount focus ought to be on learners' acquisition of 21st Century Skills rather than rushing to attain them within specific timeframes or through a sheer quantity of activities. Instruction can still be fast-paced however standards do not have to be neglected in order to place great focus on learner acquisition of the 4Cs. Mere incorporation of these skills into mathematics classroom activities is insufficient; teachers must be deliberate in nurturing and assessing these skills through meaningful opportunities. It is important to acknowledge that profound institutional change takes time, and achieving policy intentions requires collective efforts from all stakeholders within the Zambian education system. While teachers' views and attitudes are crucial, they alone cannot drive effective implementation. Unfortunately, there was a notable lack of adherence to 21st century core values in the teaching of mensuration, necessitating solutions involving school management and teachers themselves. To pursue

21st century education effectively, hands-on learning experiences and learner-centered teaching strategies cannot be disregarded. When executed correctly, 21st century education can offer a superior educational experience and equip learners to make substantial contributions to the global economy upon completion.

In conclusion, the elements that the P21 Framework (2008) alluded to as part of the five elements of the critical support systems identified include assessment of 21st Century Skills, 21st century curriculum and instruction as well as 21st century learning environments were of fundamental influence to the findings of this study in that these elements are what both the teachers and learners ought to have for a successful curriculum integration; integration of 21st Century Skills in the mathematics classroom in the teaching and learning of mensuration. The challenges that were mentioned by the teachers also pointed to the three elements of the critical support system of P21 Framework.

6.3 Recommendations

Arising from the findings of this study, it is recommended that:

i. The Ministry of Education in Zambia should facilitate Knowledge and Innovation Exchange initiatives for mathematics teachers which would provide an opportune window to support capacity development, knowledge exchange and innovation work on 21st Century Skills.
ii. The Ministry of Education should prioritize investments in technological infrastructure such as educational software, online simulations, interactive whiteboards etcetera in secondary schools to support mathematics teacher's efforts towards learners' acquisition of 21st Century Skills.
iii. The mathematics teacher training institutions in Zambia should escalate the inclusion of ICT-based activities at the training stage since ICT skills supports learner acquisition of the 4Cs.
iv. The curriculum development center in Zambia should include clearly defined rubrics in the secondary school mathematics curriculum which are consistent with assessment of 21st Century Skills by teachers of mathematics.

Mathematics teachers should include the following for successful integration of 21st Century Skills in secondary school mathematics classroom practice:

v. Incorporate Project-Based Learning (PBL) to cultivate collaboration, critical thinking, creativity, and communication skills in learners.

vi. Integrate technology into mathematics instruction to enhance digital literacy and develop the 4Cs: critical thinking, creativity, communication, and collaboration. Mathematics teachers should make efforts to identify and implement appropriate software applications that support mathematics instruction, particularly in areas like mensuration.

vii. Provide specific and constructive feedback to learners on problem-solving strategies, communication, and technology use to support the acquisition of 21st Century Skills.

viii. Design mathematics tasks that stimulate critical thinking, creativity, clear communication, and collaborative problem-solving, aligning with the demands of the 21st century.

This study has offered valuable insights into Mathematics Teachers' Classroom Practices in the Context of 21st Century Skills, focusing on a selected STEM secondary school in Lusaka District, Zambia. The research endeavor was pursued with the aim of shedding light on various aspects related to the integration of 21st Century Skills into mathematics education. Specifically, the study aimed to investigate the objectives laid out at the beginning of this research journey. The study's findings as intimated in Chapter 4, suggest promising future research directions in mathematics education and the integration of 21st Century Skills in Zambia. Potential research areas include assessing the effectiveness of teacher training, enhancing the curriculum framework, studying resource allocation impact, conducting longitudinal studies, and comparing practices across regions or schools. These avenues have the potential to inform policies and practices for holistic learner and educator development in the 21st century.

In addition to the challenges and recommendations highlighted, this study contributes valuable insights to the body of knowledge in Mathematics Education in several ways. Firstly, it sheds light on the specific challenges faced by mathematics teachers in integrating 21st Century Skills into their classroom practices, particularly in the context of mensuration instruction. By identifying these challenges, the study provides a nuanced understanding of the obstacles that hinder effective integration and suggests targeted interventions to address them.

Secondly, the study underscores the importance of professional development and training programs tailored to the needs of mathematics teachers. By emphasizing the need for comprehensive workshops and ongoing support, the study advocates for capacity-building initiatives that empower educators to leverage technology and adopt learner-centered approaches in their teaching. Furthermore, the study

highlights the role of curriculum development and assessment practices in promoting the acquisition of 21st Century Skills among learners. By identifying deficiencies in current assessment methods and curriculum frameworks, the study advocates for reforms that prioritize the alignment of learning objectives, assessment criteria, and instructional strategies with the demands of the 21st century.

Generally, by elucidating the challenges and opportunities inherent in integrating 21st Century Skills into mathematics education, this study enriches understanding of effective pedagogical practices and contributes to the ongoing discourse on educational reform. It provides valuable insights that can inform policy decisions, curriculum development efforts, and professional development initiatives aimed at enhancing the quality of mathematics education and preparing learners for success in the 21st century.

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APPENDICES

APPENDIX 1: Semi-Structured Interview Schedule for Teachers (A)

Questions

1. What is your professional qualification?
2. How many years have you been teaching mathematics in the Ministry of General Education?
3. What do you know about the core values of the Zambia revised curriculum of 2013?
4. What skills and competencies is society demanding of citizens today and explain why.
5. What is the importance and how does it benefit learners by in cooperating the aforementioned skills in the teaching and learning process?
6. What is required of you as a teacher in ensuring that learners acquire the skills mentioned earlier?
7. What teaching strategies can you employ in order to promote learner acquisition of these skills?
8. What are the outcomes of mathematics at grade eleven in relation to learners attaining the listed skills above?
9. Is there a way you are expected to teach with regards to the revised curriculum of 2013? Explain.
10. In terms of classroom-based assessment, is there a way you are supposed to assess learners with regards to the revised curriculum of 2013? Explain.
11. Is there anything you would like to add on that you feel would enhance our discussion in regards to the skills that society is demanding today?

Thank you so much for your cooperation!

APPENDIX 2: Lesson Observation Schedule for Teachers and Learners.

Consists of Two (2) Sections A and B.

School code……. **Teacher's code……**

Time……

Date…….

Number of learners: Boys……, Girls…….

SECTION A: Learners

NO.	**SKILLS**	**ASPECTS**	**WHAT IS OBSERVED**	**COMMENTS**
1	Creativity and Innovation	a. Learners compare different ways of approaching traditional mathematical problems and find innovative solutions, using practical examples where appropriate.		
		b. Learners listen to and evaluate others' reasoning and offer improvements and corrections, with supporting arguments. They listen to others' feedback and modify their own arguments as needed. They learn from mistakes, and make repeated attempts at solving problems.		
		c. Learners look for patterns that suggest creative shortcuts or simplifying frames of reference. They make generalizations from patterns they observe in repeated calculations.		

		d. By discovering fresh insights and communicating them to others, learners come to understand that mathematics is a creative endeavor that builds on previous knowledge.		
2	Critical Thinking and Problem Solving	a. Learners look for a logical structure in addressing mathematical challenges. They are able to make complex choices and construct viable arguments to defend their choices.		
		b. Learners identify and ask significant questions about mathematics and engage in analyzing each other's answers.		
		c. Learners make sense of applied mathematical problems through analysis and synthesis of evidence, and persevere in solving problems		
		d. Learners analyze how parts of a whole interact with each other in mathematical systems.		
3.	Communication and Collaboration	a. Learners articulate mathematical thoughts and ideas using oral and written communication skills.		
		b. Using abstract and quantitative reasoning with attention to precision, they construct viable arguments and analyze others' reasoning.		

		c. Learners listen effectively to the reasoning of peers. They rephrase another learner's explanation or engage in questioning in order to decipher a peer's solution to a mathematical problem.		
		d. Construct viable arguments and critique the reasoning of others		
		e. Attend to precision. Look for and express regularity in repeated reasoning		
4	Information, Communications, and Technology (ICT) Literacy	a. Learners use tools such as graphing calculators, spreadsheets, computer graphing, computer algebra systems, GPS devices, and online resources appropriately and strategically.		
		b. Learners use technology to communicate mathematical insights by constructing appropriate graphical representations of functions and of data.		

SECTION B: Teachers

NO.	**ASPECTS**	**WHAT IS OBSERVED**	**COMMENTS**
1.	Kind of tasks used to assess learners		
2.	Under what conditions learners complete the given assessments		
3.	Theories of mathematics learning are reflected in the design of the mathematics task/activities used		
4.	Make use of multiple approaches for analyzing and teaching each knowledge point		
5.	Make the learning environment more interactive		
6.	Teachers' questioning techniques		
7.	Give ample time to the learners to reflect on their tasks		
8.	Provide feedback to the learners		
9.	Enable learners to generate their own ideas		
10.	Encourage use of technology in the classroom		
11.	Allow learners to employ various problem-solving strategies		
12.	Kind of guidance the teacher provides learners with during a task		
13.	Teaching strategies employed by the teacher		
14.	Provide opportunities for Learners to make predictions and hypotheses, try other solutions and discuss them.		
15.	Provide opportunities for other learners to present and reflect findings in front of the class.		

GENERAL OBSERVATION:

……

……

……

……

……

APPENDIX 3: Semi-Structured Interview Schedule for Teachers (B)

Questions

1. What can you tell me about this class of learners?
2. What do you understand by curriculum integration?
3. How do you experience curriculum changes in the teaching of mensuration especially with regards to the revised 2013 curriculum?
4. In your view, do you think these changes are improving the quality of teaching of mensuration?
5. What were the expected learning outcomes from these lessons on mensuration?
6. How would these expected learning outcomes benefit the learners?
7. How will you know that learners have learnt what you hoped they would learn from the whole topic mensuration?
    - Give an example from lessons I observed you on in mensuration.
8. In your class, I noticed that you instructed learners to work in groups. What was the main aim?
9. I also noticed that you asked learners to show their findings on the board. Would you explain the main reason behind that?
10. What kind of tasks or activities do you use when teaching mensuration?
    - When assessing the learners in the topic mensuration, what do you look for?
11. Are there any other resources for mathematics asides the mathematics classroom?
12. What mainly do you focus on as you prepare the lesson plan on mensuration?
13. What characteristics do you think are eminent in the teaching and learning process in your lessons on mensuration?
14. What comes to your mind when you hear the concept of 21st Century Skills?
15. Do you incorporate the 21st Century Skills in the teaching of mensuration?
    - If yes, how do you incorporate these skills in your teaching and learning?
16. How do you ensure that learners acquire the aforementioned skills?
17. Do you have a preferred way of teaching mensuration?
    - If yes, tell me about it?
18. Do you think there are specific areas of those lessons on mensuration that you would improve?
19. Which experiences do you feel would best prepare you to teach mathematics in a 21st century classroom?

End of interview and thank you so much for sparing me your time.

APPENDIX 4: Document Analysis Checklist

Document	**Specific items**	**Comment**
Lesson plans	• Learning outcomes: are they linked to the 21st Century Skills outcomes of grade 11 mathematics. • Examples: are there real-life examples. • Teaching approaches/ strategies: learner centered. • The kinds of tools that were used in the lessons.	
Records of work	• If all the learning outcomes were met in the whole topic taught with regards to 21st Century Skills	
Assessment tools	• Are the kinds of assessment tools used to assess learners aligned with 21st Century Skills? • If the assessments used were challenging enough for the learners. • If the assessments were linked to the outcomes of grade 11 mathematics.	

APPENDIX 5: Performance Assessment for Learners

Observation framework for the 4 Cs in mathematics education adopted from Smit (2016).

Aspect	**What is observed?**
1. General Comment:	
2. Creativity	
1a. Be fluent and flexible	
1b. Be original/novel	
1c. Be elaborate	
3. Critical thinking	
2a. Posing questions and arguments with or about a (mathematical) problem that can lead to solving the problem and provide clarification for their choices or limiting conditions.	
2b. Check source reliability	

2c. Explicitly describe and check inferences	
2d. Analyze connections between mathematical information related to the problem and evaluate the big picture(authenticity)	
2e. Evaluate (own) thinking. Learners are asked to explain justify and defend their ideas.	
4. Communication	
3a. Clear oral communication	
3b. Clear written communication	
5. Collaboration	
4a. Provide and receive feedback	
4b. Make decisions together	
4c. Committed participation and shared responsibilities.	

APPENDIX 6: Ethics Approval Letter

THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka 10101 | **Tel:** +260-290 258/291 777
Fax: (+260) 211 290 258/253 952 | **Email:** director.drgs@unza.zm | **Website:** www.unza.zm

APPROVAL OF STUDY

IORG No. 0005376
HSSREC IRB No. 00006464

24th August, 2022

REF NO. HSSREC-2022-JUL-019B

Chantell Bwalya Chileshe
The University of Zambia
School of Education
Department of Mathematics and Science Education
P.O. Box 32379
LUSAKA

Dear Ms. Chileshe,

RE: "MATHEMATICS CLASSROOM PRACTICES IN THE CONTEXT OF 21ST CENTURY SKILLS: A CASE OF SELECTED SECONDARY SCHOOLS IN LUSAKA"

Reference is made to your submission of the protocol captioned above. The HSSREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. HSSREC-2022-JUL-019B
Approval and Expiry Date	Approval Date: 24th August, 2022	Expiry Date: 23rd August, 2023
Protocol Version and Date	Version - Nil.	23rd August, 2023
Information Sheet, Consent Forms and Dates	☐ English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	
Number of Participants Approved for Study		

Towards Improving Service and Excellence in High Education Beyond Fifty Years

APPENDIX 7: Letter of Permission from the Ministry of Education

All communications should be addressed to
The Permanent Secretary, Ministry of Education
Not to any individual by name

Telephone: 250855/ 251315/ 251283
251293/ 211318/ 251291
251003/ 251319

MOE/101/1/11
In reply please quote
No. .....

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION

P. O. BOX 50093
LUSAKA

4th October, 2022

Ms. Chantell Chileshe Bwalya (0964 271719)
C/O University of Zambia
LUSAKA.

REF: PERMISSION TO CONDUCT RESEARCH – YOURSELF

The above subject matter refers.

I am pleased to inform you that the Ministry of Education has granted you permission to collect data for research purposes in secondary schools under Lusaka District, Lusaka Province. Your research is restricted to your topic titled **"Mathematics classroom practices in the context of 21st Century Skills: a case study of selected schools Lusaka".**

Be informed that the during the data collection period, you will be required to exhibit high levels of professionalism, discipline and integrity, failure to which this permission will be terminated.

Furthermore, ensure that the information collected is purely used for academic purposes.

By copy of this minute, the District Education Board Secretary, Lusaka District, is informed accordingly.

Ignatius Daka
Director - HRA
For/ Permanent Secretary - Administration
MINISTRY OF EDUCATION

APPENDIX 8: Participants' Informed Consent Form

HSSREC FORM 1b

THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES
HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE

Telephone: +260-211-290258/293937
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PARTICIPANT INFORMATION SHEET

Name of Principle Investigator: Chantell Bwalya Chileshe

Name of Organization: University of Zambia

Informed Consent Form for: Teachers/Learners

This informed consent form is for teachers of mathematics who will be teaching grade elevens at the time of the research, as well as their learners in selected secondary schools in Lusaka district. I am inviting them to participate in my research which is specifically for academic purposes and is titled "Mathematics Classroom Practices in the Context of 21st Century Skills. A Case Study of David Kaunda National STEM Secondary School in Lusaka District.

Part I: Information Sheet

Introduction

I am a postgraduate student in the school of Education pursuing a Masters' Degree in Mathematics Education at the University of Zambia. I am conducting a study on Mathematics Classroom Practices in the Context of 21st Century Skills, a Case Study of a Secondary School in Lusaka District, Zambia.

You have been selected to be one of the respondents in this study. You are free to consult anyone about this research. You may take time to consult and reflect over your decision whether to participate in this study or

not. This consent form may contain words you do not understand. You are therefore urged to seek clarification from the researcher.

Purpose of the research

The Zambia Education Curriculum Framework (2013) promotes the acquisition of knowledge, skills and values. The key competences include critical thinking and problem solving, creativity and innovation, entrepreneurship, self-management, communication, and cooperation. However, there is a disconnection between the vision of education and the reality of the classroom becoming more evident with the gap between the skills required by the society and the economy for young people to integrate and perform competently in the labour force (Care, 2020). The main purpose of this study is to seek evidence of the 4Cs (learning and innovation skills; communication, collaboration, creativity and critical thinking) in secondary school mathematics classroom.

Type of Research Intervention

This research will involve your participation in two semi-structured pre and post lesson interviews which will take 30mins one and a half hour respectively, a classroom lesson observation and performance assessments during the teaching of the whole topic Mensuration and finally document analysis.

Participant Selection

You are being invited to take part in this research because we feel that your experience and responses as teachers and grade 11 learners of mathematics in a secondary school can contribute much to our understanding and knowledge of the integration of 21st Century Skills in the secondary school mathematics classroom.

Voluntary Participation

The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed earlier.

Procedures

I am asking you to help me learn more about integration of 21st Century Skills in in the mathematics classroom in your school. I am inviting you to take part in this research project. If you accept, you will be asked to take part in the pre and post lesson interview which will just be between you and me. This discussion will be guided by myself.

The interviews will take place in one of the school offices or any secluded place, and no one else except me and you will be part of the interview, unless you want someone to be present. The entire interview will be tape-recorded, but no-one will be identified by name on the tape. The tape will be kept in my locker which is always locked and am the one who has the keys. The information recorded is confidential, and no one else except me will have access to the tape. The tapes will be destroyed after the whole research process at the end of this academic year.

Making you comfortable, I can also answer questions about the research that you may want to ask me. Then I

will ask you questions about integrating of 21st Century Skills in the mathematics classroom and give you time to share your knowledge. The questions will be about the core values of mathematics in the revised curriculum, what you understand by integrated curriculum, the challenges you face in teaching the mathematics classroom and the solutions you think can address those challenges. I will also ask questions about integration of 21st Century Skills in the teaching and learning of mathematics in your school, how are the skills being implemented in the mathematics classroom, how the assessments are designed, what classroom activities are learners engaged in with regards to learner acquisition of these skills.

I will observe you in all the lessons you will have on any mathematics topic and I request that you feel free and act in a natural way as though am not there. The lesson observations will be video recorded and the video will be kept confidential and locked in my locker in which am the only one who has access. I will share with you the findings of my research at an appropriate time if you so wish.

During the interview, I will sit down with you in a comfortable place in one of the school or any secluded place. If you do not wish to answer any of the questions during the interview, you may say so and the interviewer will move on to the next question. No one else but the interviewer will be present unless you would like someone else to be there. The information recorded is confidential, and no one else except Chantell Bwalya Chileshe will access to the information documented during your interview. The entire interview will be tape-recorded, but no-one will be identified by name on the tape. The tape will be kept in my locker which is always locked and am the one who has the keys. The information recorded is confidential, and no one else except me will have access to the tape. The tapes will be destroyed after the whole research process at the end of this academic year.

Duration

The research takes place in three months' time. During that time, I will visit you the first time for an interview which may last for at least 30mins. Then observe all the lessons on the topic integers with your grade eleven learners, after observing the lessons I will have other interviews with you which will last for an hour. During the interviews you may not respond to the questions you do not wish to respond to. Just to follow up on what I would have observed and gotten from the interviews; I will have a focus group discussion with the learners from the class I will observe you which will last four about 1 hour.

Uses of information

The information we shall get from you will be used help making decisions which might justify stakeholders' expectations of mathematics teachers' integration of 21st Century Skills in the teaching and learning of mathematics at secondary school level. It will enlighten policy makers in Zambia on the relationship between policy intentions and classroom realities. The information may be used for resource purposes for Zambian policy makers, teachers, teacher institutions, researchers and the general public.

Risks

We are asking you to share with us some very personal and confidential information, and you may feel uncomfortable talking about some of the topics. You do not have to answer any question or take part in the discussion interview if you don't wish to do so, and that is also fine. You do not have to give us any reason for not responding to any question, or for refusing to take part in the interview.

Benefits

There will be no direct benefit to you, but your participation is likely to help us find out more about how 21st Century Skills are integrated in the teaching and learning in a secondary school mathematics classroom. This may be of great benefit to the curriculum developers and all stake holders that were involved in the revision of the Zambian education curriculum.

Reimbursements

You will not be provided any incentive to take part in the research.

Confidentiality

The research is being conducted solely for academic purposes and any information shared will be treated as strictly confidential the information that we collect from this research project will be kept private. Any information about you will have a number on it instead of your name. Only the researchers will know what your number is and we will lock that information up with a lock and key.

Sharing the Results

The knowledge that we get from this research will be shared with you before it is made widely available to the public. We will publish the results so that other interested people may learn from the research.

Right to Refuse or Withdraw

You do not have to take part in this research if you do not wish to do so, and choosing to participate will not affect your job or job-related evaluations in any way. You may stop participating in the interviews and lesson observation at any time that you wish without your job being affected. I will give you an opportunity at the end of the interviews and lesson observation to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact me Chantell Bwalya Chileshe on 0964271719/ 0978317255 or email me on chantellchileshe@gmail.com.

If you wish to find about more about the IRB, contact:
Dr. Jason Mwanza, Chairperson, Humanities and Social Sciences, Research Ethics Committee,
University of Zambia
P O Box 32379
LUSAKA.

OR

Professor. Henry M. Sichingabula Director, Directorate of Research and Graduate Studies,

University of Zambia
P O Box 32379
LUSAKA.

Part II: Certificate of Informed Consent

I have been invited to participate in research about the integration of 21st Century Skills in the teaching and learning of mathematics at Secondary School level in Lusaka District. The necessary aspects and procedures to ensure successful implementation at classroom level of such include teaching approaches and strategies, Classroom activities, as well as formative assessments. I have read the foregoing information or it has been read to me. I have had the opportunity to ask questions and any questions I have asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Print Name of Participant_____
Signature of Participant _____
Date _____
Day/month/year

If illiterate [1]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____ Thumb print of participant

Signature of witness _____

Date _____
Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

[1] A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

A copy of this ICF has been provided to the participant.
Print Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____

Date _____
Day/month/year

CONTACTS FOR QUESTIONS (Names, addresses and phone numbers of the following):

1. **Principal Investigator (Must be a local person and a Zambian).**

Names: Chantell Bwalya Chileshe

Phone: +260 964271719/ 978317255

Email: chantellchileshe@gmail.com

Physical address: The University of Zambia, Department of Mathematics and Science P.O Box 32379, Lusaka.