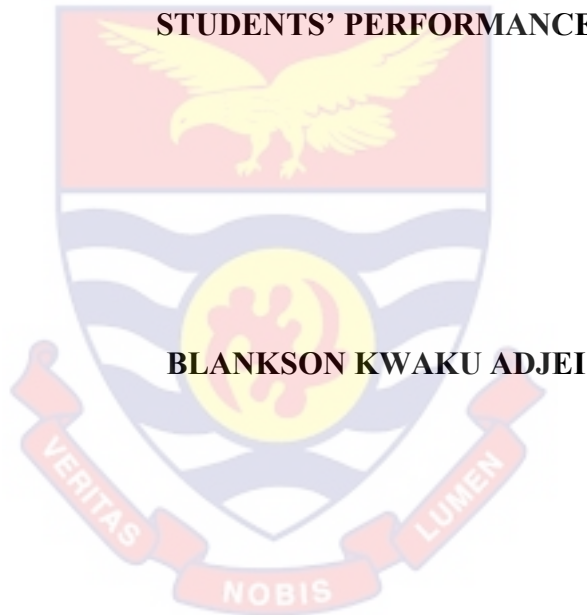


UNIVERSITY OF CAPE COAST

**INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-
BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND
STUDENTS' PERFORMANCE**



BLANKSON KWAKU ADJEI

2025

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University of Cape Coast



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MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS'
PERFORMANCE

BY

BLANKSON KWAKU ADJEI

Thesis submitted to the Department of Business and Social Sciences
Education of the Faculty of Humanities and Social Sciences Education,
College of Education Studies, University of Cape Coast, in partial fulfilment
of the requirements for the award of Doctor of Philosophy Degree in
Curriculum and Teaching

JULY 2025

DECLARATION**Candidate's Declaration**

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature:



Date:

24/07/2025

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Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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24-07-2025

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ABSTRACT

The study examined the influence of teachers' knowledge on standards-based mathematics curriculum (SBMC) implementation and students' performance in the Techiman Municipality. A mixed-method approach, specifically a sequential explanatory design with a follow-up explanation model variant was employed to address the research questions and hypotheses raised. A census sampling of 942 public primary teachers, 70% of students in a class were selected through a simple random procedure and 33 teachers were chosen purposively through an "extreme (or deviant) case sampling for a follow-up interview. TKSBMCQ, SMPT and TIG were employed to collect data. The return rate of the TKSBMCQ (803 teachers), SMPT ($n = 803$) and 21 teachers' interviews were used for the analysis. Quantitative data was addressed using both descriptive (mean, standard deviations, skewness and kurtosis) and inferential (One-way MANCOVA, One-way ANCOVA and Hierarchical multiple linear regression) statistics while the qualitative data was analysed thematically. It was found that in all the sub-dimensions addressing teachers' content, pedagogical, pedagogical content and contextual knowledge about the SBMC, teachers demonstrated moderate knowledge. Also, in all the sub-dimensions addressing SBMC implementation, teachers demonstrated moderate implementation except for ICT implementation which teachers demonstrated low implementation. Teachers' pedagogical, content and contextual knowledge about SBMC had a significant effect on teachers' implementation while teachers' pedagogical content knowledge did not. Teachers' content knowledge about SBMC had a significant effect on students' performance while teachers' pedagogical content, pedagogical and contextual knowledge had no influence. It was recommended that the Municipal Education Directorate and headteachers should strengthen and intensify in-service and continuous professional development training programmes and encourage teachers' commitment to increase their knowledge and implementation.

KEYWORDS

Content Knowledge (CK)

Contextual Knowledge (CtK)

Curriculum

Implementation

Knowledge

Pedagogical knowledge (PK)

Pedagogical content knowledge (PCK)

Standards-based curriculum (SBC)

Standards-based mathematics curriculum (SBMC)

Students

Students' performance

Teachers

Teachers' knowledge

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DEDICATION

To my daughter, Kendra Adom Owusu Adjei, Wife Mrs Abigail Opoku and the entire family.

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LIST OF ACRONYMS

AMP	African Mathematics Project
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
AVE	Average Variance Extracted
CBC	Competency-Based Curriculum
CC	Core Competencies
CCSSM	Common Core State Standards of Mathematics
CK	Content Knowledge
CPD	Continuous Professional Development
CR	Composite Reliability
CRDD	Curriculum Research and Development Division
CtK	Contextual Knowledge
DL	Differentiated Learning
DoBSSE	Department of Business and Social Sciences Education
DSP	Differentiation and Scaffolding Pedagogy
DVs	Dependent Variables
EFL	English as a Foreign Language
ELB	Expected Learning Behaviours
EMM	Estimated Marginal Means
GES	Ghana Education Service
GMS	Ghana Mathematics Series
GSS	Ghana Statistical Service
HTMT	Heterotrait-Monotrait Ratio

ICT	Information and Communications Technology
IEC	Instructional Expectations of the Curriculum
IEP	Inclusion and Equity Pedagogy
ITE	Initial Teacher Education
IVs	Independent Variables
JHS	Junior High School
JSP	Joint School Project
KAP	Knowledge, Attitudes and Practice
KCC	Knowledge of the Core Competencies
KD	Knowledge Domain
KDSP	Knowledge of Differentiation and Scaffolding Pedagogy
KELB	Knowledge of Expected Learning Behaviours
KICTPT	Knowledge of ICT as a Pedagogical Tool
KIEC	Knowledge of Instructional Expectations about the Curriculum
KIEP	Knowledge of Inclusion and Equity Pedagogy
KL	Knowledge of the Learner
KLC	Knowledge of Learning Contexts (Classroom, School, Community and Culture)
KLCP	Knowledge of Learner-Centred Pedagogy
KLL	Knowledge of Learners' Learning
KOSC	Knowledge about Organisation and Structure of the Curriculum
KRAP	Knowledge of Recommended Assessment Practices
LCP	Learner-Centred Pedagogy

MANCOVA	Multivariate Analysis of Covariance
MANOVA	Multivariate Analysis of Variance
MPRA	Model of Pedagogical Reasoning and Action
MOE	Ministry of Education
MOESS	Ministry of Education, Science and Sports
NaCCA	National Council of Curriculum and Assessment
NCLB	No Child Left Behind
NCTM	National Council of Teachers of Mathematics
NGOs	Non-Government Agencies
NMS	National Minimum Standards
NPECF	National Pre-tertiary Education Curriculum Framework
NTECF	National Teacher Education Curriculum Framework
OSC	Organisation and Structure of the Curriculum
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
PLC	Professional Learning Community
RAP	Recommended Assessment Practices
RNG	Random Number Generator
SBC	Standards-Based Curriculum
SBMC	Standards-Based Mathematics Curriculum
SDG	Sustainable Development Goal
SMPT	Students' Mathematics Performance Test
SPSS	Statistical Product and Service Solutions
TIG	Teachers' Interview Guide

TKSBMCQ	Teachers' Knowledge about the Standards-Based Mathematics Curriculum Questionnaire
TMA	Techiman Municipal Assembly
UCC-IRB	University of Cape Coast Institutional Review Board
UDL	Universal Design of Learning
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNSDG	United Nations Sustainable Development Goal
VIF	Variance Inflation Factor
WARMP	West African Regional Mathematics Project
ZPD	Zone of Proximal Development

CHAPTER ONE

INTRODUCTION

Implementation of curriculum reform is a crucial process since it determines how the planned curriculum purpose is achieved. Due to its relevance, stakeholders monitor with key interest. Since Ghana introduced a standards-based curriculum in the basic schools in September 2019, issues of poor implementation resulting from teachers' inadequate knowledge and preparation for the implementation have been raised (Kpedator, 2019; Agormedah et al., 2022). However, it appears that much attention of current research on the standards-based curriculum has been on teachers' implementation concerns to the neglect of whether teachers possess the required knowledge of content, pedagogical, pedagogical content and contextual knowledge and how it influences the implementation and students' performance. Reported findings of teachers' concerns about the implementation show concerns about textbooks (Aboagye & Yawson, 2020; Agormedah et al., 2022), a short period of training (Mahama, 2022), insufficient workshops (Ayebi-Arthur, Addulai & Korsah, 2020), collaboration and support from stakeholders (Apau, 2021), and information about the curriculum (Mpuangnan & Adusei, 2021). If the issue of poor implementation is not addressed, its consequences are enormous. It could affect the curriculum's smooth implementation. To do this, teacher knowledge is a crucial factor in the process. Therefore, this study examines teachers' knowledge of content, pedagogical knowledge, pedagogical content, and contextual knowledge about the standards-based mathematics curriculum and its influence on implementation and students' performance.

Background to the Study

Curriculum reform is conceived by people from different perspectives. For this reason, it is viewed from different angles. In spite of this, generally, curriculum reforms aim at making changes in the school curriculum to improve educational outcomes. Curriculum reform is a global phenomenon in any country's educational policy. Curriculum determines the educational direction and the kind of society we want to build (Ojong & Maduka, 2013). Hence, the curriculum undergoes continuous reforms to make it meet the changing demands of society. Since Ghana attained independence in 1957, several educational and curriculum reforms have been implemented to address Ghanaians' changing needs (Agormedah et al., 2022). Notable among them include the 1951 plan on accelerated development, the 1961 Education Act, reforms in 1974 led by Dzobo, reforms in 1987, and Josephus Anamuah-Mensah led reforms in 2007 (Adu-Gyamfi, Donkoh & Addo, 2016).

The previous pre-tertiary education curriculum in Ghana adopted an objective-based curriculum approach (NaCCA, 2019). It is a teacher-centred curriculum which stresses the importance of setting objectives to guide lesson planning and teaching activities (Malan, 2000). The objective-based curriculum orientation is traced to Tyler (1949) and many other scholars (Malan, 2000). According to NaCCA (2019), the previous objective-based curriculum merely promotes passing examinations. Therefore, to be able to meet the 21st-century skills needs which include thinking critically, being creative, utilising technological skills, applying knowledge to solve societal problems, and raising the pre-tertiary education level quality, a standards-based curriculum is introduced in Ghana (NaCCA, 2019).

Ghana adopted a new standards-based curriculum in basic schools in September 2019 (MOE, 2019). The standards-based curriculum is the kind of curriculum that focuses on standards, competencies, knowledge, skills, attitudes and values learners are to demonstrate, and activities that will allow learners to reach goals stated in the standards (Siedentop et al., 1986; as cited in Lund & Tannehill, 2014). Similarly, the standards-based curriculum “has standards to be achieved across the educational system by identifying the knowledge, skills and dispositions that learners should know and be able to demonstrate. It also specifies activities leading to the attainment of specified standards” (NPECF, 2018, p.29).

Historically, standards-based curriculum is traced to standards-based reforms. Hamilton, Stecher and Yuan (2008) argue that standards-based reforms include “academic expectations for students (what students should know and be able to do), alignment of the key elements of the educational system to promote attainment of these expectations, and using the assessment of student achievement to measure outcomes” (p. 2). Standards-based reforms started in the United States in the late 1970s, consequently leading to curriculum standards publication. Curriculum standards are “indicators of quality that specify expectations for students” (Earl & Graham, 1995, p. 58). It also constitutes things students are expected to know and do, measure or benchmark which defines dimensions of performance or learning domains (Cox, Weinstein, Marfan & Munoz, 2013). The National Council of Teachers of Mathematics (NCTM, 1989) initially published “Curriculum and Evaluation Standards for School Mathematics”, which has undergone several revisions to date.

As a result of this paradigm shift, many countries including Ghana have adopted standards-based reforms (Agormedah et al., 2022; MOE, 2018). For instance, the United Kingdom, Australia, and New Zealand have adopted standards-based reforms. Equally, in Africa, standards-based reforms have led to a review of the school curriculum in most countries. For instance, Rwanda and Kenya adopted a competency-based curriculum in 2015 and 2017 respectively. Competency-based curriculum is a curriculum which is similar to a standards-based curriculum. Other countries that have embraced a competency-based curriculum include Cameroon, South Africa, Nigeria, Zambia, Ethiopia and Tanzania (Kanyonga, Mtana & Wendt, 2019; Nsengimana, Rugema-Mugabo, Hiroaki & Nkundabakura, 2020; Ruth & Ramadas, 2019).

The National Pre-tertiary Education Curriculum Framework (NPECF, 2018) of Ghana indicates that the essence of moving away from an objective-based curriculum to a standards-based curriculum is to de-emphasise the practice of merely passing an examination, to building learners of good character, values, and confidence. Also, to make learners literate and think critically so as to contribute to national discourse and development. Therefore, the standards-based curriculum recommends that learners be engaged actively to develop core competencies which include “critical thinking and problem-solving, creativity and innovation, communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy” for national development (NaCCA, 2019, p. vi-vii).

As part of this prime objective, the standards-based curriculum across all subject domains recommends certain core pedagogical approaches which

include learner-centred pedagogy such as inquiry-based learning activities, discovery-based learning activities, group work and discussion, experiential-based learning activities, problem-solving activities, cooperative learning activities, and collaborative-based activities (NaCCA, 2019; NPECF, 2018). Others are differentiation and scaffolding pedagogy, ICT integration, effective questioning techniques for deep learning, and integration of meaningful assessment practices (NaCCA, 2019; NPECF, 2018). In addition to this, understanding the organisation and structure of the curriculum in terms of its strands, sub-strands, content standards, and indicators as well as expected learning behaviours and instructional expectations is essential to ensuring that the curriculum is implemented effectively.

Curriculum implementation is a critical stage of the curriculum development process. It entails putting the intended or designed curriculum into actual classroom practice to achieve its purpose (Afangideh, 2009; Ibeh, 2022), and the engagement between the teacher and the learner regarding classroom activities (Ogar & Opoh, 2015). That is, translating curriculum expectations, rationale, philosophy, objectives, aims, goals, content, prescribed pedagogies, recommended assessment strategies and other relevant aspects of a curriculum into actual classroom practice. For this to be realised effectively, the teacher factor in terms of knowledge needs to be considered. Teacher knowledge as conceived by Verloop, Van Driel and Meijer (2001) constitutes “all the profession-related insights which are potentially relevant for teachers’ activities” (p. 1). To Shulman (1986, 1987) and others (Abell, 2008; Carlsen, 1999; Grossman, 1990), teacher knowledge for effective teaching includes content, pedagogical, pedagogical content and contextual knowledge.

Consistent with this, Ben-Peretz (2011) argues that teacher knowledge constitutes one or more of the knowledge domains suggested by Shulman which include “content knowledge, pedagogical knowledge, pedagogical content knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes and values and their philosophical and historical grounds”.

Teachers’ knowledge is key to teaching and learning. It affects students’ understanding and achievement of a subject (Abell, 2007). Also, the knowledge of teachers shapes the learning environment and conceptual understanding of students (Heck, 2009). It is believed that the kind of knowledge teachers possess for classroom practice goes a long way to influencing students’ learning. Hill, Rowan and Ball (2005) reveal teachers’ mathematical knowledge contribution to students’ gains in mathematics achievement. Due to this, teachers’ role in a new curriculum implementation is emphasised in many studies (Hargreaves, 2005; Harris & Graham, 2019; Priestley, Edwards, Priestley & Miller, 2012). Chaudhary (2015) alludes to the fact that, during curriculum implementation, interaction exists between the learner and the planned learning activities through teachers’ mediation. This competence requires teachers’ knowledge of subject content, pedagogical training and the experiences they have in teaching (Farrant, 2014).

It may also be argued that when it comes to mathematics curriculum implementation, teachers’ knowledge is critical because teachers as final implementers have the choice to decide which aspects of the curriculum need to be selected for implementation. Limited and insufficient knowledge of the curriculum and its content leads to teachers not adopting a new curriculum

(Mandukwini, 2016). Rudhumbu and Rudhumbu (2018) further point out that in implementing a mathematics curriculum, teachers' knowledge and education influence how the curriculum is effectively implemented. Similarly, Garcia and Dela-Rosa (2021) reveal how teachers' knowledge of teaching methodologies and strategies influences school mathematics curriculum implementation. For this reason, it is believed that getting teachers motivated to implement innovation is to enhance their knowledge (Kagama, 2018). This suggests the need for a holistic view of teachers' knowledge when it comes to curriculum implementation to achieve the desired purpose of any curriculum.

However, gaps in teachers' knowledge pertaining to curriculum implementation manifest themselves in the knowledge domains suggested by Shulman (1986, 1987). These knowledge domains include "content knowledge, general pedagogical knowledge, curricular knowledge, pedagogical content knowledge (PCK), knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational purposes, values and their philosophical and historical bases". In a similar vein, the gap in teachers' knowledge is witnessed in teaching orientation, curriculum, assessment, students' understanding, and instructional strategies (Magnusson, Krajcik & Borko, 1999). Beggs (2000) also finds that teachers' gap in knowledge relates to their integration of ICT tools into classroom practices.

The aforementioned gaps are being noticed when it comes to curriculum implementation. For instance, Ampadu (2013) finds inconsistencies in teachers' pedagogical practices regarding a new mathematics curriculum implementation. Momanyi and Rop (2019) report teachers' lack of adequate knowledge and skills as the major factor hindering the smooth implementation of a

competency-based curriculum. Similarly, Kanyonga, Mtana and Wendt (2019) find that competency-based curriculum implementation is challenged due to teachers' limited understanding and preparation.

Concerning the standards-based curriculum implementation since September 2019, the issue of whether teachers of basic schools are adequately prepared and possess the required knowledge has been highlighted (Agormedah, 2022; Kpedator, 2019). This trend is consistent with the aforementioned studies. However, it appears much attention of current researchers regarding the standards-based curriculum implementation has been on teachers' concerns about textbooks (Aboagye & Yawson, 2020; Agormedah et al., 2022), inadequate workshops (Ayebi-Arthur, Addulai & Korsah, 2020), issue of collaboration and support from stakeholders (Apau, 2021), issue of information about the curriculum (Mpuangnan & Adusei, 2021), and teachers' teaching efficacy beliefs (Agormedah et al., 2022), to the apparent neglect of whether teachers of basic schools possess the required knowledge of content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum, its influence on the implementation and students' performance. Additionally, the extent to which the standards-based mathematics curriculum is being implemented is left unattended. Therefore, it was imperative to assess teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about the standards-based mathematics curriculum, its influence on implementation and students' performance. In light of this, the study sought to assess the influence of teachers of basic schools' knowledge about the standards-based mathematics curriculum on their implementation and students' performance.

Statement of the Problem

The problem investigated is the inadequate implementation of the standards-based curriculum as a result of teacher ineffectiveness. This problem is highlighted by the report of NaCCA (2022) that the implementation of the standards-based curriculum is poor. The report revealed that most teachers have limited knowledge of the standards-based curriculum and they were not trained on the standards-based curriculum. Also, teachers do not use creative pedagogies in implementing the curriculum. These issues from NaCCA's report, therefore, raised concerns about teachers' knowledge in implementing the curriculum.

Further, this concern (i.e. teacher ineffectiveness) is supported by Ntumi et al.'s (2023) study in six Ghanaian regions, which found that teachers struggle with lesson preparation when it comes to implementing the curriculum. Additionally, Agormedah et al. (2022) found that teachers' own assertion of their teaching efficacy regarding the standards-based curriculum implementation was not encouraging in terms of how they engage learners, how they manage the classroom and the strategy of their instruction.

This challenge is due to teachers' inadequate knowledge and preparation regarding the standards-based curriculum (Kpedator, 2019). In support of this, Mahama (2022) discovered that the majority of in-service teachers exhibited low nurturing behaviours in creativity concerning the standards-based curriculum implementation which indicated the teachers' limited knowledge of the curriculum's core competencies. Similarly, Arthur and Obeng's (2023) study disclosed that 56.2% of teachers sometimes had difficulty identifying strategies in teaching some sub-strands of the standards-based curriculum. In

addition, Addai-Mununkum and Setordzi (2023) identified teachers' deficiencies in creativity skills and knowledge of the core competencies regarding the standards-based curriculum implementation in primary schools which were key for the curriculum's implementation. The issue of teacher knowledge concerning the standards-based curriculum implementation may not be different in the Techiman Municipality.

If the issue of inadequate implementation is not addressed, its ramifications are enormous. For instance, the consequences are that nationally, the intended purpose, aspirations and objectives of the curriculum may not be achieved. Teachers, students and society on the other hand, may not realise the significance of introducing the new curriculum. To address this, teachers' knowledge is a key factor in curriculum implementation. For example, Asare (2022) alludes to the role teachers' pedagogical skills play in standards-based curriculum implementation.

However, it appears that since the standards-based curriculum implementation in September 2019, much attention of researchers in Ghana has been focused predominantly on teachers' concerns about the standards-based curriculum implementation. Recent findings show teachers' concerns about textbooks (Aboagye & Yawson, 2020; Agormedah et al., 2022), a short period of training (Mahama, 2022), insufficient workshops (Ayebi-Arthur, Addulai & Korsah, 2020), issues of collaboration and support from stakeholders (Apau, 2021), and issues of information about the curriculum (Mpuangnan & Adusei, 2021).

Regarding the implementation of the standards-based mathematics curriculum since 2019, the above-mentioned studies looked purely into

standards-based computing curriculum (Ayebi-Arthur, Addulai & Korsah, 2020), while others (Aboagye & Yawson, 2020; Agormedah et al., 2022; Apau, 2021; Mahama, 2022; Mpuangnan & Adusei, 2021) investigated the standards-based curriculum in a general perspective without a reference to the standards-based mathematics curriculum. It appears from these studies that particular attention has not been paid to the standards-based mathematics curriculum regarding basic school teachers' knowledge and implementation. However, numerous studies have emphasised the value and influence of standards-based mathematics curricula in the classroom (Budak, 2015; Edward et al., 2021).

It appears from the aforementioned studies that much attention has not been focused on whether teachers of basic schools possess the required knowledge of content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum, its influence on implementation and students' performance. Further, there seem to be no studies that have assessed whether teachers' knowledge of content, pedagogical knowledge, pedagogical content and contextual knowledge regarding the standards-based mathematics curriculum have any effects on their implementation and students' performance, controlling for the effects of their years of experience in teaching, age and gender.

Additionally, it appears that no studies have assessed whether teachers' knowledge of content, pedagogical knowledge, pedagogical content and contextual knowledge about the standards-based mathematics curriculum differ across their academic qualifications, mode of certificate acquisition and grade levels, controlling for the effects of their years of experience in teaching, age and gender. Moreover, it seems like no studies have investigated whether

teachers' standards-based mathematics curriculum implementation differs across their grade levels, controlling for the effects of their years of experience in teaching, age and gender.

It is found that teachers' knowledge significantly influences their curriculum implementation (Chemagosi, 2020; Kisulu, Simatwa & Ndolo, 2021; Kosgei, 2015; Rwigema & Andala, 2022; Sidow, 2022;), and students' academic performance (Adeniyi, Ogundele & Odetola, 2014; Ali, Busch, Qaisrani & Rehman, 2020; Damien & Claire, 2022; Hakim, 2015; Kiamba, Mutua & Mulwa, 2017; König et al., 2021; Nyanjom, Yambo & Ongunya, 2020; Olasehinde-Williams, Yahaya & Owolabi, 2018; Yasin, 2021). Also, there exists evidence to suggest that teachers' knowledge significantly differs across their years of experience in teaching (Al-Awidi & Aldhafeeri, 2017; Madani & Forawi, 2019). Again, teachers' gender (Anderson, 2020; Nyagah & Gathumbi, 2017), age (Anderson, 2020), educational level (Nyagah & Gathumbi, 2017) and qualifications (Owusu & Yiboe, 2013) have been found to significantly influence their curriculum implementation. Additionally, there is evidence to suggest that teachers' knowledge and awareness about curriculum implementation differ significantly across their academic qualifications (Madani & Forawi, 2019). However, since the implementation of the standards-based mathematics curriculum, none of the previously mentioned studies delved into these variables.

It is therefore argued that, to ensure an effective curriculum implementation, the knowledge of teachers regarding content, pedagogical knowledge, pedagogical content and contextual knowledge is critical in the process. Also, how this knowledge influences the implementation and students'

performance is key. Further, how this knowledge about the standards-based mathematics curriculum and its implementation differs across academic qualifications, mode of certificate acquisition and grade levels, controlling for the effects of teachers' years of experience in teaching, age and gender is indispensable. Therefore, this current study sought to investigate these regarding the standards-based mathematics curriculum in the Techiman Municipality.

Purpose of the Study

The purpose of this study was to examine the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance.

Objectives of the Study

These specific objectives guided this study. This study sought to examine basic school teachers':

1. Content knowledge about the standards-based mathematics curriculum in the Techiman Municipality.
2. Pedagogical knowledge about the standards-based mathematics curriculum in the Techiman Municipality.
3. Pedagogical content knowledge about the standards-based mathematics curriculum in the Techiman Municipality.
4. Contextual knowledge about the standards-based mathematics curriculum in the Techiman Municipality.
5. Assess the extent of basic school teachers' implementation of the standards-based mathematics curriculum in the Techiman Municipality.

6. Assess whether a significant difference exists in teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about the standards-based mathematics curriculum across their academic qualifications, mode of certificate acquisition and grade levels, controlling for the effects of years of experience in teaching, age and gender.
7. Determine whether a significant difference exists in teachers' standards-based mathematics curriculum implementation across grade levels, controlling for the effects of years of experience in teaching, age and gender.
8. Ascertain whether there are any significant effects of teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about standards-based mathematics curriculum on implementation of the curriculum, controlling for the effects of years of experience in teaching, age and gender.
9. Assess whether there are any significant effects of teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about standards-based mathematics curriculum on students' academic performance, controlling for the effects of years of experience in teaching, age, gender and students' age.

Research Questions

This study was guided by these research questions:

1. What is the content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?

2. What is the pedagogical knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?
3. What is the pedagogical content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?
4. What is the contextual knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?
5. What is the extent of basic school teachers' implementation of the standards-based mathematics curriculum in the Techiman Municipality?

Hypotheses of the Study

These Null Hypotheses (Ho) were tested:

Ho1. There is no significant difference in teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum across their academic qualifications, mode of certificate acquisition, and grade levels, controlling for the effects of years of experience in teaching, age and gender.

Ho2: There is no significant difference in teachers' standards-based mathematics curriculum implementation across grade levels, controlling for the effects of years of experience in teaching, age and gender.

Ho3: There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum on implementation of the curriculum, controlling for the effects of years of experience in teaching, age and gender.

H04: There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum on students' academic performance, controlling for the effects of years of experience in teaching, age, gender and students' age.

Significance of the Study

The findings of this study may benefit stakeholders of education like the Techiman Municipal Education Directorate, headteachers, teachers, the Ghana Education Service, the Government of Ghana and the Ministry of Education in a number of ways. First and foremost, the Ghana Education Service's Directorate in the Techiman Municipality would be informed about the knowledge teachers of basic schools possess regarding the standards-based mathematics curriculum and its implementation. Also, the directorate would be informed about how teachers' knowledge about the curriculum might influence the curriculum implementation and students' performance. This may propel the Ghana Education Service's Directorate in the Techiman Municipality to devise a plan to build teachers' commitment and passion and also offer regular training and workshops to increase teachers' professional competencies and knowledge regarding the standards-based mathematics curriculum and its implementation.

Also, the study's findings could offer a valuable benefit to the teachers of basic schools in the Techiman Municipality. The findings would be shared with the teachers regarding their content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum, its implementation, its influence on the implementation and students' performance. Areas of their strength that would be identified would be discussed with them. This may serve as a means of enhancing their existing knowledge about the

standards-based mathematics curriculum and its implementation. Also, certain deficiencies that would be identified would be shared with them. This may encourage them to regularly involve themselves in professional development courses, programmes, training and workshops to update and develop their professional competencies and knowledge regarding the standards-based mathematics curriculum and its implementation.

Again, the study's findings could add to the insights of headteachers of basic schools in the Municipality regarding teachers of basic schools' knowledge about the standards-based mathematics curriculum and its implementation. This may encourage headteachers to offer support, provide resources and regularly organise in-service training and continuous professional development programmes for teachers. This may also encourage headteachers to design appropriate instructional practices and guidelines for teachers to increase their knowledge and improve the curriculum implementation to benefit their schools.

Additionally, the study's findings could provide a means of urging headteachers and the Ghana Education Service's Directorate in the Techiman Municipality to direct much attention to enhancing teachers' knowledge about the curriculum and its implementation. The findings may encourage headteachers and the Municipal Education Directorate to intensify training and workshop programmes on standards-based mathematics curriculum and its implementation for teachers. This could be a way to increase the knowledge of teachers and the implementation of the curriculum.

In a similar vein, the study's findings might offer a way of urging the Government of Ghana and the Ministry of Education to speed up the delivery

of resources and tools to schools. Equally, through the study's findings, the Municipal Education Directorate of Techiman and headteachers may be encouraged to liaise with Non-Governmental Agencies (NGOs) to get more resources and tools for schools. The study's findings could also assist the headteachers in urging the Municipal Education Directorate of Techiman to post dedicated and committed teachers to enhance the curriculum's implementation.

Likewise, the findings could provide useful input for the designers of the basic school curriculum to prioritise teachers' knowledge and consider it critically before curriculum design and implementation. The findings may encourage designers of school curricula to engage teachers and take into consideration teachers' knowledge and its relation to curriculum implementation since teachers' knowledge could influence curriculum delivery. This could help designers in deciding what ought to be included in the basic school curriculum.

Moreover, the study's findings could offer valuable insights for school authorities in basic schools, teachers and other educational stakeholders to appreciate learners' worldviews and performance regarding the standards-based mathematics curriculum implementation. The knowledge and appreciation of learners' worldviews on teaching practices could provide an opportunity to strengthen students' engagement in the teaching and learning process. The study's findings might inform teachers to pay attention to learners' own emotions and beliefs, interests, prior experiences and background. This could lead to enhancing students' involvement in classroom practices.

Finally, the study's findings may add to the existing literature and also provide a premise for other researchers to carry out further studies in areas such

as the influence of teachers' perceptions, beliefs, attitudes and motivation on standards-based mathematics curriculum implementation and students' performance. The study's findings may also provide a means for a similar study to be carried out in Junior High Schools and Private Schools. Equally, the study's findings may provide a means for an additional study to be initiated to ascertain the influence of other teachers' demographic characteristics on standards-based mathematics curriculum implementation and students' performance. Researchers may be advised to look into these areas to add to the conversations on the study's topic. It is anticipated that this could potentially contribute to improvement in the standards-based mathematics curriculum implementation in basic schools.

Delimitation

The study was narrowed to teachers' knowledge of content, pedagogical, pedagogical content, and contextual knowledge about standards-based mathematics curriculum, its influence on implementation and students' performance. Content knowledge variables include teachers' knowledge of the organisation and structure of the curriculum, expected learning behaviours, instructional expectations and core competencies of the standards-based mathematics curriculum. Pedagogical knowledge variables include teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and ICT. Pedagogical content knowledge variables include teachers' knowledge of learners' (students') learning and assessment practices, while contextual knowledge variables include teachers' knowledge of learning contexts (classroom, school, community and culture) and the learner.

Again, the study was restricted to how teachers' knowledge about the standards-based mathematics curriculum could predict their implementation and students' performance. In addition, the study concentrated primarily on public basic school teachers, specifically primary school teachers and students in the Techiman Municipality, Bono East Region. The study was confined to public primary school teachers and students because they have experienced the implementation for a longer period since it was implemented in September 2019. Therefore, they could provide better insight, hence their inclusion. In contrast, their counterparts, teachers in Junior High school, started implementing the standards-based mathematics curriculum in January 2022, not long ago, hence their exclusion.

Limitations

The study has a number of limitations. Firstly, the study should have included all the private primary schools in the Techiman Municipality. However, owing to financial resources and time, the study was confined to only public primary schools within the Municipality. Hence, the findings of the study only apply to such a limited number of teachers and students from the public primary schools who were involved in the study.

Also, the study should have included a broad range of factors such as resource availability, teachers' beliefs, attitudes, motivation and value for the new curriculum that could influence the implementation. Similarly, the study should have included a wide range of factors such as students' learning environment and socio-economic status that could influence their academic performance. However, the study concentrated on teachers' knowledge about the standards-based mathematics curriculum, its influence on implementation

and students' performance. Other factors not considered could affect the data even though the researcher controlled factors such as teachers' years of experience in teaching, age and gender that could influence their knowledge and curriculum implementation. In the same vein, the researcher controlled students' age which could influence their academic performance.

Again, the study should have included classroom observation to have a further appreciation of teachers' implementation of the curriculum. However, this could not be done due to time, training of multiple observers and logistical constraints. In addition, employing a sequential explanatory design with a follow-up explanation model variant comes with its own challenges, especially the qualitative data collection in the second phase.

Definition of Terms

For this study, the following terms are interpreted and explained as follows:

Content knowledge: This entails teachers' knowledge of the organisation and structure of the curriculum (e.g. strands, sub-strands, content standards, indicators), expected learning behaviour, instructional expectations and core competencies about the standards-based mathematics curriculum.

Pedagogical knowledge: This refers to teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and ICT about the standards-based mathematics curriculum.

Pedagogical content knowledge: This refers to teachers' knowledge of learners' learning and assessment practices about the standards-based mathematics curriculum.

Contextual knowledge: This refers to teachers' knowledge of learning contexts (classroom, school, community and culture) and the learner about the standards-based mathematics curriculum.

Implementation: refers to putting the standards-based mathematics curriculum into practice in the classroom.

Students' academic Performance: refers to learners' mathematics achievement scores obtained from the students' mathematics performance test (SMPT)

Mode of certificate acquisition: refers to the means by which teachers acquire their academic qualifications, through distance, sandwich, regular and part-time.

Knowledge: refers to teachers' understanding of content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum.

Organisation of the Study

The study is organised into five chapters. Chapter Two covers theoretical, conceptual and empirical reviews of the study. Chapter Three deals with the research approach and design, research paradigm, study area, population, sample and sampling procedures, data collection instruments, validity and reliability of instruments, data collection procedures, data processing and analysis, and ethical considerations. Chapter Four discusses results based on the research questions and the hypotheses, while Chapter Five gives a summary of the findings, recommendations and conclusions of the study.

CHAPTER TWO

LITERATURE REVIEW

Overview

This study examines the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. The chapter provides the perspectives of researchers, scholars and other authorities concerning the topic under consideration. For purposes of clarity, this study was organised into subheadings. These include the theoretical and conceptual frameworks, conceptual and empirical reviews.

The conceptual review covers the post-independence development of the mathematics curriculum in Ghana, the historical background of the standards-based curriculum, the standards-based curriculum in Ghana, and its philosophy. Additionally, it covers teachers' knowledge and curriculum implementation, teachers' content knowledge and curriculum implementation with a focus on knowledge of the organisation and structure of the curriculum, expected learning behaviours (learning domains), instructional expectations, and core competencies. Teachers' pedagogical knowledge and curriculum implementation with a particular reference to knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, and ICT as a pedagogical tool. Teachers' pedagogical content knowledge and curriculum implementation with a concentration on knowledge of learners' (students') learning, and assessment practices. Teachers' contextual knowledge and curriculum implementation with a focus on knowledge of learning contexts (classroom, school, community and culture), and the learner (student).

The empirical review presents studies on teachers' mathematics curriculum implementation, the influence of teachers' knowledge on curriculum implementation, the influence of teachers' knowledge on students' academic performance, teachers' knowledge, demographic characteristics and curriculum implementation. The Chapter ends with a summary of the literature.

Theoretical Framework

This study was anchored on two main theoretical perspectives. These are the theories of Shulman (1986, 1987) regarding knowledge of teachers, and Rogan and Grayson's (2003) theoretical perspective for implementing curriculum. These theories underpinned the study because the variables under consideration in the study could be best addressed by using these theoretical lenses.

The Theory of Shulman (1986, 1987) Regarding Knowledge of Teachers

In the teacher education context, more consideration has been focused on understanding what constitutes teachers' knowledge for teaching since the 1980s (Fernandez, 2014). In line with this, Shulman has been regarded as very instrumental in describing teachers' knowledge (Fernandez, 2014). Shulman's (1986, 1987) theory regarding knowledge of teachers served as the basis for teaching.

Shulman (1986) proposes teacher knowledge into subject matter content knowledge, pedagogical content knowledge, and curricular content knowledge (Lotivio-Bedural, Ali, Sapriya, & Disman, 2019). According to Shulman, content knowledge understanding should not be restricted only to concepts or facts about the content but rather extended beyond these to the structures of the content. Thus, knowing the concepts or the facts of the content is not enough,

rather, teachers should be equipped to understand structures and the organising principles as well (Shulman, 1986). For this reason, Shulman (as cited in Ball, Thames & Phelps, 2008) argues that teachers must not only understand what something is but move further to ascertain why it is so. On the other hand, Shulman (1986) considers pedagogical content knowledge (PCK) as ‘the most useful’ aspect of teachers’ knowledge needed to represent the content. The curricular content knowledge in Shulman’s (1986) view is:

the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances (p. 10).

This conceptualisation provides a further basis for inquiry into teacher knowledge by Shulman in 1987.

In an effort to further expand the initial theory regarding teacher knowledge, Shulman (1987) in an article titled “Knowledge and Teaching: Foundations of the New Reform”, proposed seven components of teachers’ knowledge for successful teaching. These are: “content knowledge, general pedagogical knowledge, curricular knowledge, pedagogical content knowledge (PCK), knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes and values, and their philosophical and historical grounds”. These have been illustrated in Figure 1.

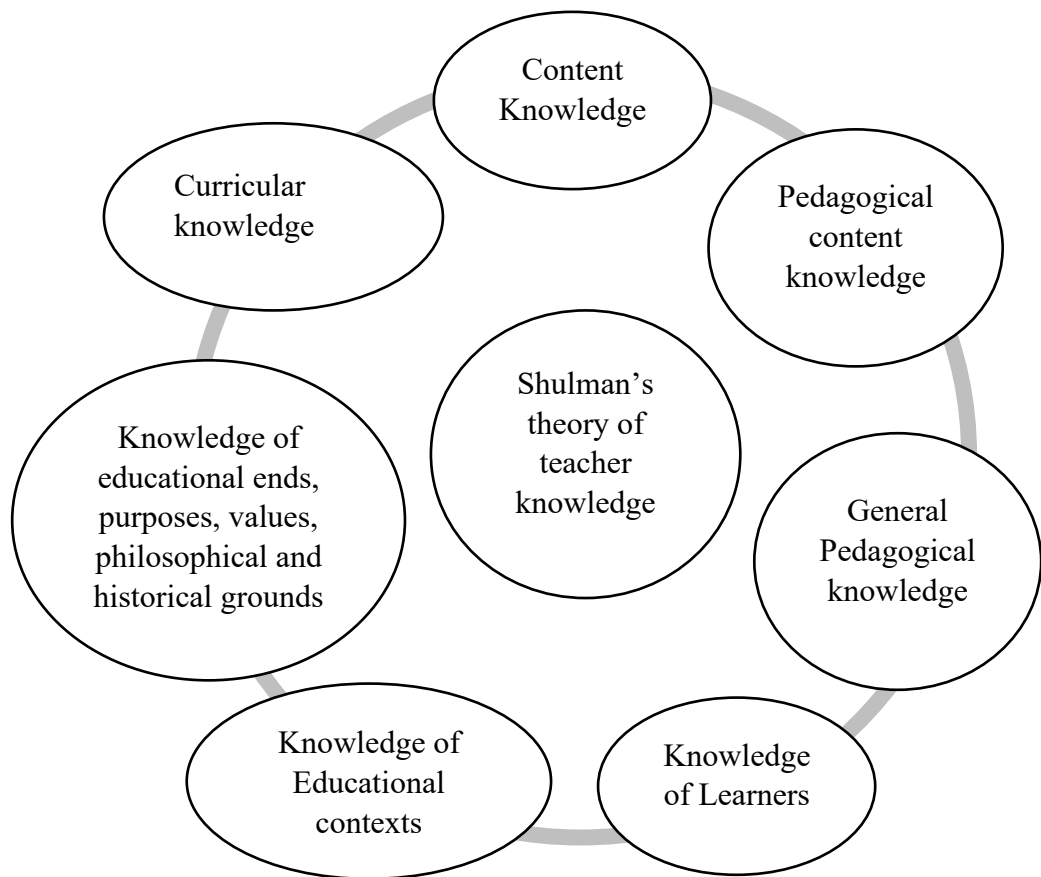


Figure 1: The theory of Shulman (1987) regarding knowledge of teachers

In addition to an initial explanation of curricular content knowledge, Shulman (1987) classifies curricular content knowledge into alternative curricular knowledge, lateral curricular knowledge, and vertical curricular knowledge. Lateral curricular knowledge constitutes teachers' knowledge and capacity to associate particular subject content with other subjects. Vertical curricular knowledge entails teachers' knowledge and familiarity with topics in terms of previous, present and topics to be taught in preceding years, while alternative curricular knowledge refers to teachers' knowledge and understanding of supplementary materials for teaching a subject (Shulman, 1987 cited in Bagherzadeh & Tajeddin, 2021).

Shulman (1987) explains general pedagogical knowledge in terms of teachers' knowledge of broad principles and classroom management strategies

as well as general instructional activities. Shulman further indicates that teachers' general pedagogical knowledge complements their content and pedagogical content knowledge. Shulman (1987) additionally presents a model of pedagogical reasoning and action (MPRA) comprising six components to explain teachers' classroom pedagogical activities. They are: "comprehension, transformation, instruction, evaluation, reflection and new comprehension". Building on Shulman's explanation, other views have been espoused. For instance, Voss and Kunter (2013) consider general pedagogical knowledge not just restricted to the scope of classroom management but encompassing an understanding of the complex demands of the entire classroom situation. Darling-Hammond (2000) maintains that teachers' general pedagogical knowledge involves teachers' knowledge in dealing with various pedagogical tasks and other demands in classroom situations. In addition to classroom management, Buyong, Mohamed, Satari, Abu-Bakar and Yunus (2020) consider teachers' pedagogical knowledge as knowledge of teaching strategies, reflection, interaction and classroom communication.

Knowledge of educational contexts as explained by Shulman (1987) includes teachers' knowledge and understanding of the working classroom, governance, and finance as well as knowledge of the culture and community within which the educational system operates. Building on Shulman's view of contextual knowledge, Grossman (1990) sums contextual knowledge into the knowledge of students (learners), community, school, and district. Carlsen (1999) further subdivides contextual knowledge into specific context knowledge and general educational context knowledge. Specific context knowledge entails knowledge of the classroom and students and general

educational context knowledge covers knowledge about the community, school, and nation in which education is organised. Thus, contextual knowledge is the teachers' appreciation of teaching and learning which reflects the learner, classroom, environment, culture, community and background experiences of the learner.

Dealing with Shulman's conception of teachers' knowledge for teaching, others have expanded it. In some cases, divergent positions have been offered. For instance, Carlsen (1999) postulates that general pedagogical knowledge comprises knowledge of learners and learning, classroom management, general curriculum and instruction. Even though Grossman (1990) agrees with this position by indicating that general pedagogical knowledge entails knowledge of learners and learning, classroom management, general curriculum and instruction, Grossman includes 'others' as a further component.

Magnusson, Krajcik, and Borko (1999) view pedagogical content knowledge (PCK) for science teaching as knowledge of curriculum, students' understanding, assessment, instructional strategies, and orientation to teaching. Morine-Dersheimer and Kent (1999) on the other hand view content knowledge, curriculum knowledge, pedagogical knowledge, assessment procedures knowledge, as well as learners' knowledge and learning as directly linked to pedagogical content knowledge (PCK).

Therefore, drawing from Shulman's (1986, 1987) theoretical basis for teacher knowledge and other conceptions of teacher knowledge (Carlsen, 1999; Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Morine-Dersheimer & Kent, 1999), this study focuses on teachers' content, pedagogical, pedagogical

content and contextual knowledge. However, variables demonstrating these four knowledge areas were modified to suit the study. For instance, content knowledge variables include teachers' knowledge of the organisation and structure of the curriculum (e.g. strands, sub-strands, content standards, indicators), expected learning behaviours, instructional expectations and core competencies of the standards-based mathematics curriculum. Pedagogical knowledge variables include teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and ICT as a pedagogical tool. Pedagogical content knowledge variables entail teachers' knowledge of learners' (students') learning, and assessment practices, while contextual knowledge variables cover teachers' knowledge of learning contexts (classroom, school, community and culture) and the learner.

This was done to appreciate teachers' knowledge about the standards-based mathematics curriculum, its influence on implementation and students' performance. In light of this, Shulman's (1986, 1987) theoretical basis for teacher knowledge and other conceptions of teacher knowledge (Carlsen, 1999; Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Morine-Dershimer & Kent, 1999) were deemed fit to guide this study.

Rogan and Grayson's (2003) Theoretical Perspective for Implementing a Curriculum

In order to further appreciate the influence of teacher knowledge on standards-based mathematics curriculum implementation and students' performance, Rogan and Grayson's (2003) theoretical perspective regarding curriculum implementation was deemed fit to further explore the teacher factor.

This theoretical perspective considers the teacher factor as one of the key determinants of effective curriculum implementation.

Rogan and Grayson (2003) postulate in their curriculum implementation theory three major factors that influence effective curriculum implementation. These are: “profile of implementation, capacity to innovate and outside influences” (see Figure 2, p. 31). Profile of implementation aims at appreciating how aspirations and goals of innovation are implemented in the classroom. Its sub-constructs include interaction in the classroom, classroom practical work and assessment. The capacity to innovate deals with factors which support or hinder innovation. These include the teachers’ factor to support innovation, the learners’ factor to support innovation, physical resources to support innovation and school ethos and management to support innovation. Outside influence deals with support from outside agencies or organisations that work with schools to support effective innovation. This could be assistance from donor agencies, departments of education and other organisations (Gallos, Berg & Treagust, 2005). The theoretical model of Rogan and Grayson has been represented in Figure 2.

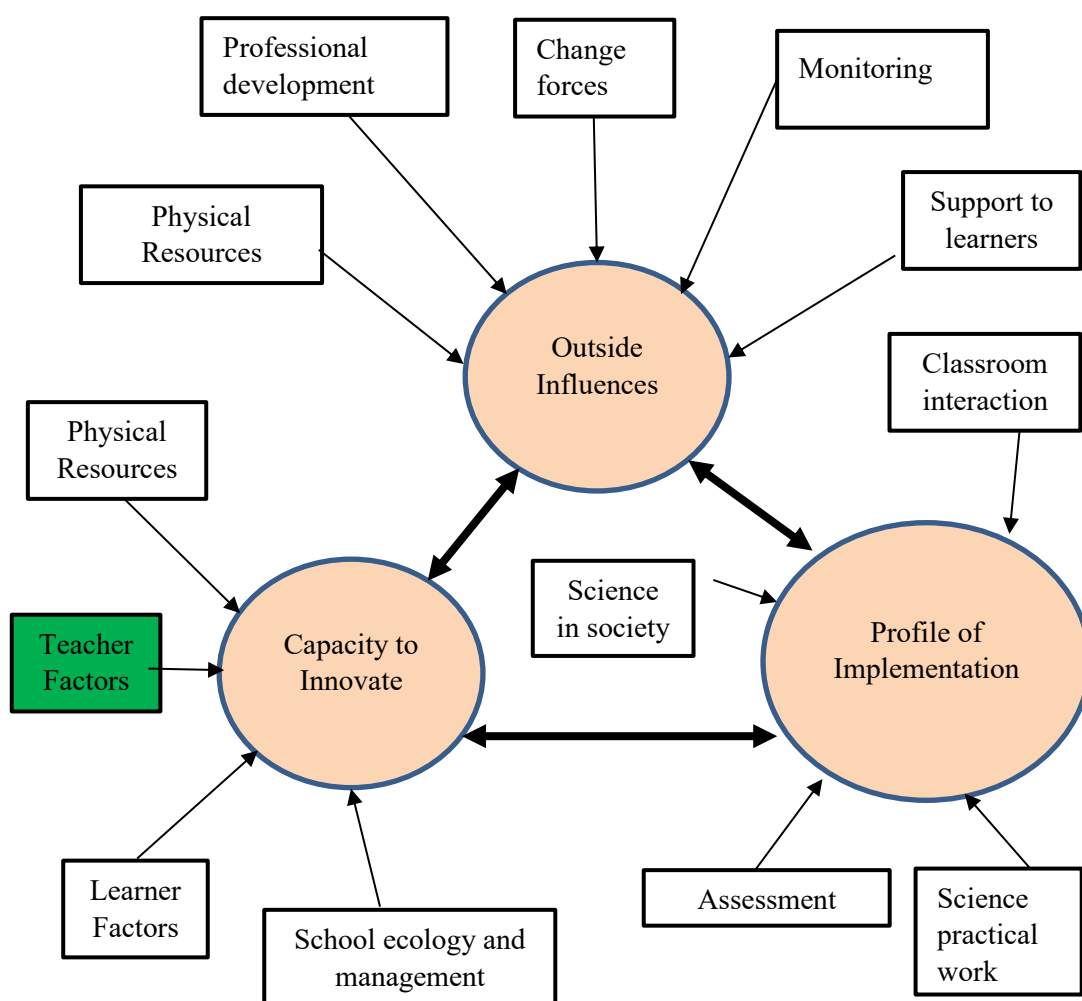


Figure 2: Rogan and Grayson's (2003) theoretical perspective for implementing a curriculum

For this study, Rogan and Grayson's (2003) construct of capacity to innovate and profile of implementation serve as an additional reference for the study. Regarding the capacity to innovate, special emphasis is placed on the teacher factor. That is the teachers' capacity in terms of the knowledge they possess to implement the standards-based mathematics curriculum. Concerning the profile of implementation, the focus is placed on teachers' classroom practices of implementing the standards-based mathematics curriculum. Teachers remain critical factors regarding curriculum innovation because teachers incorporate the intended curriculum into classroom practice. For this

reason, Rogan and Grayson (2003) maintain that teachers' limited knowledge of content could influence the implementation of an innovation. Therefore, consideration in terms of analysis of teachers' knowledge, views and perceptions towards the implementation of educational reforms should be given the needed attention since teachers are pivotal agents of change (Altinyelken, 2010; Rogan & Grayson, 2003).

Similarly, Gross, Giacquinta and Bernstein (1971) advance in their theory of curriculum implementation the necessity of the teacher factor. According to Gross et al. (1971), curriculum implementation effectiveness is a result of five conditions during the implementation process among them, the teacher factor is indispensable. They believe that teacher competence as well as their awareness and clarity about the scope and content of an innovation influence its implementation. For this reason, they argue that in curriculum implementation, the extent to which teachers or members of school organisations possess the requisite capabilities and competence for curriculum implementation is crucial. Gross (1971) argues that for effective curriculum implementation and any change in education, factors like teachers' competency, awareness and clarity about innovation, attitudes and the capacity of the implementer to implement innovation need to be considered.

In agreement, Oluoch (1982) and Shiundu and Omulando (1992) view teacher factor regarding curriculum implementation as crucial by indicating the need for providing sufficient and continuous support for teachers as a condition for effective curriculum implementation. In addition, Fullan's (2016) theoretical model of curriculum implementation emphasises three main factors influencing effective curriculum implementation which include "characteristics of change,

local characteristics and external factors”. Within local characteristics, Fullan stresses the teacher factor as an essential element influencing the curriculum implementation process. Teachers’ knowledge about reform and innovation, and their capacity to implement are important ingredients in the implementation process. “Characteristics of change deal with an appreciation of clarity, practicality, quality and need of the implementation while external factors emphasise issues such as other agencies and government that might influence curriculum implementation.

Every curriculum innovation and reform requires change agents and the key among them is the teacher factor (Orstein & Hunkins, 2004). Rogan and Grayson’s (2003) theoretical perspective of curriculum implementation considers the teacher factor as one of the key determinants for effective curriculum implementation. Hence, in assessing the influence of teachers’ knowledge on standards-based mathematics curriculum implementation, Rogan and Grayson’s curriculum implementation theory was considered useful to provide further insight into the teacher factor regarding their knowledge and practices of the curriculum.

Conceptual Framework

Drawing from the theory of Shulman (1986, 1987) regarding knowledge of teachers, and the teacher factor and profile of implementation in Rogan and Grayson’s (2003) theoretical perspective for implementing curriculum, teachers’ knowledge of content, pedagogical, pedagogical content and contextual knowledge about the standards-based curriculum for mathematics were explored. These four variables of teacher knowledge form the independent variables (IVs) of this study, while curriculum implementation and students’

performance form the dependent variables (DVs). Each of the independent variables has sub-variables or dimensions as shown in Figure 3. Also, the framework shows how the independent variables (IVs) could influence the dependent variables (DVs).

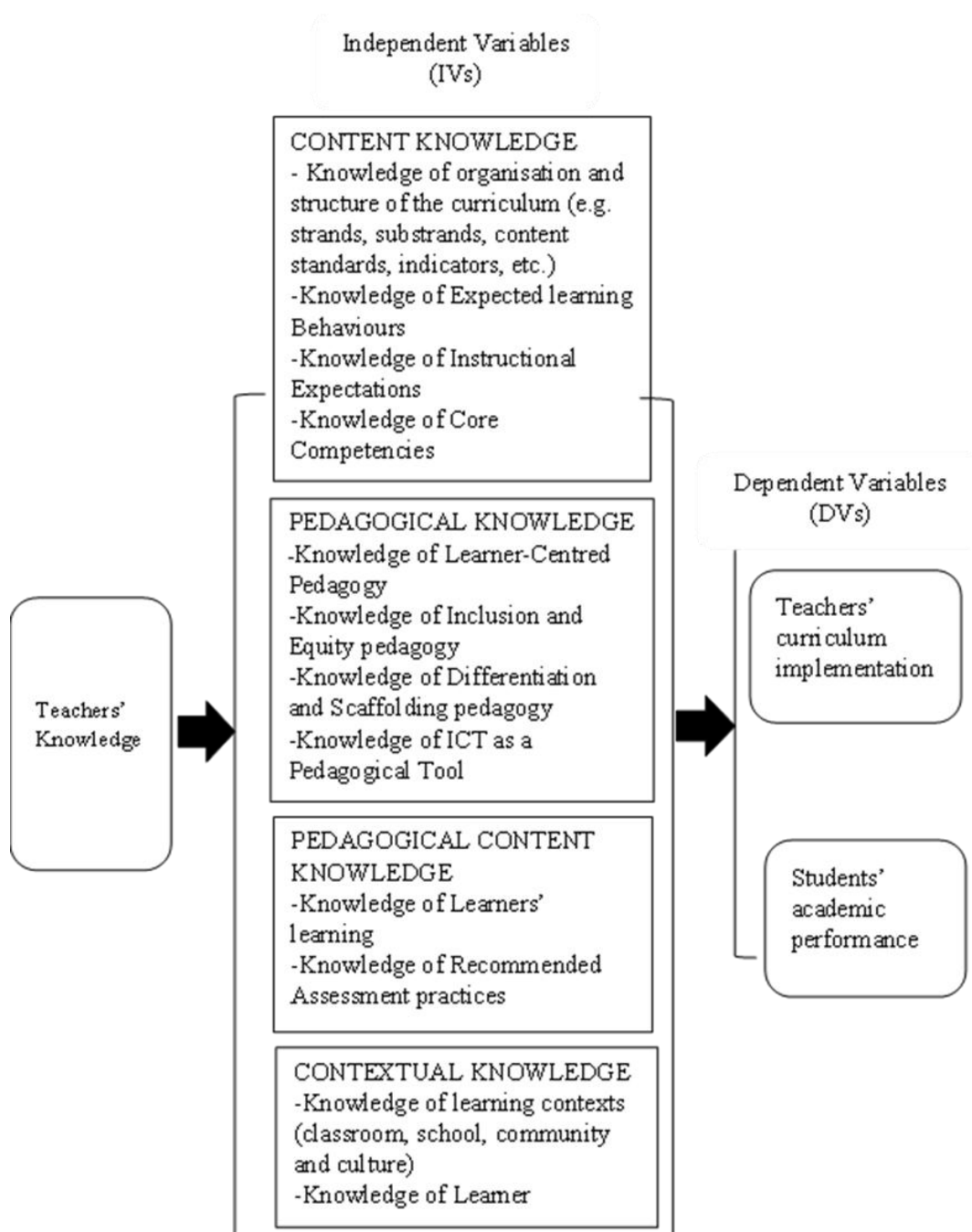


Figure 3: Conceptual framework showing the influence of teachers' knowledge on curriculum implementation and students' performance

Source: Author's own Construct, 2023

Concerning the conceptual framework in Figure 3, the first arrow from the left points to the independent variables (IVs), while the second arrow to the right points to how the independent variables (IVs) could influence the dependent variables (DVs). The independent variables (IVs) in Figure 3 include teachers' content, pedagogical, pedagogical content and contextual knowledge. The dependent variables (DVs) consist of teachers' curriculum implementation and students' performance. Each independent variable (IV) has sub-variables or dimensions. For instance, content knowledge sub-variables include knowledge of the organisation and structure of the new standards-based mathematics curriculum (such as strands, sub-strands, content standards, indicators), expected learning behaviours, instructional expectations and core competencies.

Also, the sub-variables of pedagogical knowledge comprise knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, and ICT as a pedagogical tool. The sub-variables of pedagogical content knowledge consist of knowledge of learners' learning and recommended assessment practices. In addition, the sub-variables of contextual knowledge include knowledge of learning contexts (classroom, school, community and culture), and the learner. The independent variables (IVs) and the dependent variables (DVs) of this study as shown in Figure 3 have been reviewed extensively in the subsequent sections of this chapter.

Conceptual Review

The section below provides a conceptual review of the major themes addressed in the conceptual framework. These pertain to teachers' content knowledge about the curriculum which borders on knowledge of organisation

and structure of the curriculum, knowledge of expected learning behaviour (learning domains), knowledge of instructional expectations, and knowledge of the core competencies. Teachers' pedagogical knowledge centres on knowledge of learner-centred pedagogy, knowledge of inclusion and equity pedagogy, knowledge of differentiation and scaffolding pedagogy, and knowledge of ICT as a pedagogical tool. Teachers' pedagogical content knowledge focuses on knowledge of learners' learning and assessment practice, while teachers' contextual knowledge covers knowledge of learning context (classroom, school, community and culture) and knowledge of the learner.

The conceptual review addresses the post-independence development of mathematics in Ghana, the historical background of standards-based curriculum, the standards-based curriculum in Ghana and its philosophy, and teacher knowledge (content, pedagogical, pedagogical content and contextual knowledge) and curriculum implementation.

Post-Independence Development of Mathematics Curriculum in Ghana

The school curriculum for mathematics has undergone several reforms after independence in 1957. According to Mereku (1999), this was significant due to the emergence of modern mathematics, especially in the late years of 1960s and the early years of 1970s. This led to a significant change in the selection and treatment of the content of school mathematics at all levels of pre-university in Ghana (Mereku, 1999). Also, the emergence of 'new math' contributed to the creation of many mathematics curricula. Notable ones include the African Mathematics Project (AMP) and the Joint School Project (JSP) (Mereku, 1999). These were carried out in Ghana to address the changing demands of the school curriculum for mathematics.

In 1972, Ghana introduced the first national mathematics curriculum for primary schools. The West African Regional Mathematics Project (WARMP) brought about the Ghana Mathematics Series (GMS) textbooks and their corresponding teachers' handbooks. The primary schools in Ghana received the first publication of the GMS textbooks between 1975 and 1977 (Mereku, 1999). Unfortunately, their counterparts in Junior High Schools could not receive them due to limited funds until 1988.

Subsequently, the educational reforms of 1987 also prompted school curriculum development for mathematics. In 1988, new mathematics curriculum materials were published for the primary, Junior Secondary and Senior Secondary schools spearheaded by the Curriculum Research and Development Division (CRDD) (Mereku, 1999). To mitigate some of the challenges such as the incompatibility of the GMS schemes and JSP schemes, the mathematics curriculum materials that were published in 1988 were designed to make primary school and Junior secondary school curricula content align with previously published Ghana Mathematics Series (GMS) schemes content (CRDD, 1987). According to Mereku (1999), students in both Junior and Senior Secondary Schools were made to follow similar curriculum material which was heavily loaded.

Similarly, the reforms of 2007 brought about a new mathematics curriculum in September 2007 (Ampadu, 2013). The intention was to move the school curriculum for mathematics from teacher-led to student-centred. The basis was to adopt the constructivists' teaching and learning perspective for the mathematics curriculum. It was also intended to advance students' interest in mathematics and make them actively involved in the process of teaching and

learning (Mereku, 2003 as cited in Ampadu, 2012). According to the Ministry of Education, Science and Sports (MOESS, 2007), the focus of the mathematics curriculum was to build strong mathematical competencies that could be a useful requirement for the development of other related fields such as “science, commerce, industry and a variety of other professions” (p. ii). The major content areas for the primary school level include “numbers, shape and space, measurement, collecting and handling data, and problem-solving” (p. 3). For Junior High School level, the major content areas consist of “numbers, geometry, estimation, measurement, algebra, statistics and probability” (MOESS, 2007, p. iii).

In 2012, there was a review of the existing 2007 mathematics curriculum. Among others, the rationale was to develop mathematical knowledge and skills that could eventually prepare and develop learners to acquire fundamental “numeracy competence” to operate successfully in society (Ministry of Education, 2012). Similarly, the curriculum expected that learners would be able to “use numbers competently, read and interpret numeric data, reason logically, solve problems involving calculations and mathematical reasoning, as well as communicate effectively with other people using accurate mathematical data and interpretations” (MOE, 2012, p. iv). In addition, the Junior High School curriculum was envisaged to make learners develop strong mathematical competencies that could be applied in other domains such as science, commerce, industry and other related professions (MOE, 2012). The major content areas of the 2012 primary school mathematics curriculum review include “numbers and numerals, number operations, measurement, shape and space, collecting and handling data, problem-solving and application” (MOE,

2012, p. vi). Junior High School mathematics curriculum content areas consist of “numbers and numerals, number operations and algebra, measurement, shape and space, collecting and handling data (statistics and probability), and problem-solving and application” (MOE, 2012, p. v).

It could be observed that in terms of the content areas, there were no significant changes. Hence, most of the content areas for the 2007 primary and junior high school mathematics curricula were reflected in the 2012 primary and Junior high school mathematics curricula. The teaching methods of both the 2007 and 2012 mathematics curricula emphasised the student-centred method of teaching mathematics.

However, some changes could be observed concerning the National Minimum Standards (NMS) that were emphasised in the 2012 mathematics curriculum review. The emphasis was placed on the attainment of National Minimum Standards (NMS) at primary three (3), primary six (6) and by the time student completes the JHS course. For instance, it was envisaged that by the time a student completes primary three (3) education, it is expected that the student could read, write, and order whole numbers up to a minimum of 1000, identify unit fractions, recite addition and subtraction facts, understand and use money notation, recognise shapes and solve problem by organising and interpreting numerical data (MOE, 2012).

The emphasis on National Minimum Standards (NMS) for primary 3, primary 6 and JHS was an additional feature of the 2012 mathematics curriculum review. Even though the 2007 mathematics curriculum emphasises the attainment of specific objectives, it was for the entire six years of primary education. For the Junior High School level, it was for the entire 3 years of

education at that level. This was not the case for the 2012 mathematics curriculum review.

Notwithstanding the intentions of the mathematics curriculum that was introduced in 2007 and subsequent review in 2012, the changing demands of society necessitated the need for a new mathematics curriculum to be introduced. In line with this, in September 2019, a standards-based mathematics curriculum was implemented across schools at the basic level throughout Ghana.

Historical Background of Standards-Based Curriculum

Standards-based curriculum started as a result of the standards-based reform movement in the United States. The intention was to develop standards which demonstrate competencies acquired by a learner. As much as standards-based reform is viewed from different perspectives in different contexts, Hamilton, Stecher and Yuan (2008) maintain that irrespective of the variations, standards-based reform should consist of either all or part of these characteristics:

academic expectations for students (often described as indicating what students should know and be able to do), alignment of the key elements of the educational system to promote attainment of these expectations, the use of assessments of student achievement to measure outcomes, decentralisation of responsibility for decisions relating to curriculum and instruction, support and technical assistance to foster improvement of educational services, and accountability provisions that reward or sanction schools or students on the basis of measured performance (p. 2).

In the view of Lund and Deborah (2014), a standards-based curriculum is developed by looking at standards as well as “skills, knowledge and dispositions” learners are to display to achieve the standards and the corresponding activities to meet the outcomes of the standards. Due to the relevance of a standards-based curriculum, Doolittle (2003) considers it a paradigm shift for teachers and educators.

To achieve the attainment of standards, the National Council of Teachers of Mathematics (NCTM) worked on a document titled “An Agenda for Action” in 1980. In the pursuit of this agenda, the National Council of Teachers of Mathematics (1989) published “Curriculum and Evaluation Standards for School Mathematics”. This was followed by the “Professional Standards for Teaching” (1991) and “Assessment Standards for School Mathematics” (1995). In 2000, NCTM published “Principles and Standards of School Mathematics”. These laid the foundations for standards for teaching and learning mathematics in the United States. Further, the issue of standards-based reforms became prevalent throughout the United States during the “No Child Left Behind (NCLB)” policy (Hamilton, Stecher & Yuan, 2008).

In line with the development of standards, the National Council of Teachers of Mathematics (2006) further published “Curriculum focal points for prekindergarten through grade 8 mathematics”. The intention was to pursue coherence in the standards across grade levels (Prigodich, 2021). Common Core State Standards of Mathematics (CCSSM) further consolidated school mathematics standards. In 2010, a guide for interpreting and implementing the CCSSM was provided by the National Council of Teachers of Mathematics.

Many countries including those in Africa adopted the standards-based reform curriculum in different versions with different names such as competency-based curriculum, proficiency-based curriculum and performance-based curriculum depending on the context. For instance, Tanzania, Kenya, Rwanda, Cameroon, South Africa, Nigeria and Ethiopia adopted a competency-based curriculum (Ruth & Ramadas, 2019). In 2013, Zambia revised the school curriculum in the form of an outcome-based education by embracing a competency-based curriculum (Kabombwe & Mulenga, 2019). Unlike these African countries, Ghana adopted a standards-based curriculum.

The standards-based curriculum just like the competency-based curriculum requires the “acquisition and application of learned knowledge, skills, attitudes, competencies, and values in real-life situations” (Ruth & Ramadas, 2019). In a standards-based curriculum, learners are regarded as the ones who construct their knowledge and understanding. The teacher acts as a facilitator, guide and cognitive coach (Ruth & Ramadas, 2019). The teacher is no more a dispenser of knowledge but rather creates a learning environment that facilitates learners’ construction of knowledge. Learners work in groups, discuss and share their ideas and knowledge. Therefore, a standards-based classroom learning environment serves as a community of practice. The standards-based curriculum provides a paradigm shift of pedagogical approaches that deviate from teacher-centredness to learner-centredness. Hence, a standards-based curriculum is grounded on the constructivists’ perspective of teaching and learning.

The Standards-Based Curriculum in Ghana

Standards are viewed from different perspectives in different fields. For this reason, it depicts different meanings in different fields. However, in the context of education and school curriculum, standards are “indicators of quality that specify expectations for students” (Earl & Graham, 1995, p. 58). Cox, Weinstein, Marfan and Munoz (2013) see standards as what someone needs to know and be capable of doing. They further point out that standards act as a measure or benchmark to define dimensions of performance or learning domains which are valuable and worthy of promotion. In the view of Kleinhenz and Ingvarson (2007), standards should constitute content standards, how to access the content standards and performance standards which demonstrate how a person has performed. According to them, this preposition is when standards are to be used as a measure. From these positions, standards could be described as statements that stipulate what students should understand and be capable of doing at a specific stage of their educational level. In line with this, a standards-based curriculum is considered as a “curriculum which has standards to be achieved across the educational system by identifying the knowledge, skills and dispositions that learners should know and be able to demonstrate. It also specifies activities leading to the attainment of specified standards” (NPECF, 2018, p.29).

According to the Ministry of Education (2019), Ghana’s new primary school curriculum is based on standards. As a result of the demand for skills of the 21st-century like thinking critically, being innovative, technological skills, application of knowledge to solve societal problems and so forth, most African countries have implemented a standards-based curriculum, of which Ghana is

not an exception. As captured within the National Pre-Tertiary Education Curriculum Framework (NPECF, 2018), the standards-based curriculum's justification is to:

respond to a national priority of shifting the structure and content of the education system from merely passing examinations to building character, nurturing values, and raising literate, confident, and engaged citizens who can think critically. And as an outcome, to raise the quality of education at the pre-tertiary level, with emphasis on science and mathematics as fundamental building blocks for success in either tertiary education or early entry into the workplace (p.14).

The standards-based curriculum has become necessary because, according to NaCCA (2019), the previous curriculum reforms (2007, 2012) at various levels of pre-tertiary education could not “address the fundamental concerns and challenges that inhibit learners’ opportunities to experience the education programmes and practices that will enable them to contribute to the transformation of the Ghanaian society” (NPECF, 2018, p. 15). In the view of NaCCA (2019), the previous curriculum has issues of clearly stated philosophies, goals, and aspirations that are distinctly articulated to direct the Ghanaian educational system; there are no standards for performance to direct learning, teaching, grading and assessment of students; there are no minimum national standards that describe the fundamental knowledge, skills, and attitudes that all students are entitled to as part of their national education after each cycle of education.

Moreover, as stated by NaCCA (2019), the previous objective-based curriculum focused on the acquisition of knowledge rather than measurable

standards. That is, the previous curriculum did not emphasise competence and was not centred around application and reasoning. The same source argues that the assessment regime of the previous curriculum was deficient in the sense that it did not provide effective examination outcome data to evaluate learning and teaching to enhance pre-tertiary education quality. The system of assessment was merely academic and examination driven. It was found to have contributed partly to students' low learning results (NaCCA, 2019; NPECF, 2018).

Furthermore, as stated in the NPECF (2018), the designers of the standards-based curriculum are of the view that the previous objective-based curriculum overemphasised products of learning. That is, the kind of learning that focuses on acquiring fundamental knowledge, ideas, skills and practice without considering learning processes (NPECF, 2018). Additionally, as pointed out in the NPECF (2018), the old curriculum paid less attention to the acquisition of higher cognitive competencies such as knowledge application, critical thinking, creativity, personal qualities development, and social skills. As stated in the NPECF (2018), the old curriculum did not “provide flexible education pathways for identifying and nurturing the talents and interests of learners early enough to prepare them for the world of work, career progression and sustainable development” (p.16). As a result, most graduates of the pre-tertiary education level are “functionally illiterate and ill-prepared” to continue their education, and acquiring job (NPECF, 2018).

Even though curriculum developed on an objective-based model has been instrumental and used by several advanced nations in the latter part of the 20th century, it was observed that comparing the existing curriculum to other nations (such as Singapore, Malaysia, South Korea, etc.), it was no longer

effective to meet the needs of modern-day educational practices (NPECF, 2018). Many modern changes in the world such as globalization, ICT development, climate change and the issues of a sustainable future have caused a shift in the way the school operates and therefore call for developing skills that are required for building a sustainable future (NPECF, 2018). In this regard, the old bookish curriculum could not be efficient in addressing these challenges. Hence, it became necessary to introduce a standards-based curriculum to emphasise cross-cutting essential learning that develops knowledge and skills needed for sustainable development advancement (NPECF, 2018).

Demand for educational accountability and the rigorousness of the school curriculum also informed the standards-based curriculum introduction. Stakeholders want to see evidence of learners' learning and whether it matches the satisfactory level (NPECF, 2018). Hence, the introduction of performance standards provides a reference point to assess learners' attainment of expected competencies. In this sense, learners' attainment of standards could be communicated to stakeholders. In addition to this, for Primary and Junior high school graduates to succeed in the 21st century, they need to receive an education that builds on the development of 21st century skills. The standards-based curriculum has been designed to focus on developing "critical thinking and problem-solving, creativity and innovation, communication and collaboration, cultural identity, personal development and leadership and digital literacy skills" (NPECF, 2018, p. 27). The need for inclusive education again necessitated the development of this new curriculum to ensure all students have standard education learning opportunities to fulfil United Nations Sustainable Development Goal 4 (UN SDG 4).

Standards-based education has numerous uses. It helps in deepening ideas, promotes sense-making, and engages learners (Kulm, Capraro & Capraro, 2007; Trafton, Reys & Wasman, 2001; Van de Walle, Karp & Bay-Williams, 2009). Since a standards-based curriculum focuses on learners in the process of teaching and learning, most activities in the classroom are student-centred. Hence, it engages learners through group discussion, cooperative and collaborative work, classroom inquiry, problem-solving, hands-on activities and other related forms of learning. This enhances students' participation in classroom activities. Donert (2010) further points out that standards-based education improves instruction creatively and innovatively. These suggest the necessity of standards-based curriculum reform to address 21st-century world demands.

The major strands of the Ghanaian standards-based mathematics curriculum for lower primary (Basic 1-3) and upper primary (Basic 4-6) include “numbers (counting, representation, cardinality and operations) and fractions, algebra, geometry, measurement, and handling data” (NaCCA, 2019, p. xx). The strands of the Common Core Programme for Basic 7 to Basic 10 also include numbers, algebra, geometry, measurement and handling data. Organisation and structure of the standards-based curriculum, expected learning behaviours, instructional expectations, core competencies, assessment regime and pedagogical approaches distinguish this new curriculum from the previous objective-based school curriculum.

Philosophy of the Standards-Based Curriculum in Ghana

The development of every new curriculum is underpinned by philosophical orientation(s). This possibly determines the direction of a

curriculum and serves as an analytical and evaluative tool for the intended purpose of the curriculum. For these reasons, almost every curriculum is shaped by a philosophical position. In light of this, the Ghanaian school curriculum also requires a philosophical underthought. The current standards-based school curriculum is grounded on the constructivist philosophical perspective of teaching and learning (MOE, 2019; NPECF, 2018). Before the standards-based curriculum introduction, most previously existing curricula for Ghanaian pre-tertiary education institutions were developed on the behaviourist philosophical perspective of teaching and learning (NPECF, 2018). This approach to learning mathematics has been found to encourage the direct production of responses from learned materials to demonstrate understanding and acquisition of knowledge (Sun, 2009). Boaler (2009) argues that a behaviourist-based mathematics classroom is procedural, with questions that are closed-ended and few or no questions that are open-ended and guided by a search for correct answers. As a result of these deficiencies in the behaviourists' view of teaching and learning, the current standards-based curriculum emphasises teaching and learning grounded in the constructivists' perspectives.

Generally, constructivism as a learning theory emphasises learners' construction of meaning, knowledge, and understanding of their world. As to how meaning is constructed by the learner, different views have been advanced by early proponents such as Dewey (1916), Piaget (1967), von Glasersfeld (1995) and Vygotsky (1978) in different perspectives. For instance, from the Piagetian perspective (i.e. individual constructivism or cognitive constructivism), individuals construct their meaning and understanding due to their personal experiences, prior knowledge, and independent explorations in

the environment. From the Vygotskian view (i.e. social constructivism), learners construct their knowledge and understanding due to social interactions, cultural activities, language, and assistance from a more knowledgeable person (or adult).

In agreement with Piagetian and Vygotskian viewpoints, Lambert et al. (1995) argue that learners' experiences, beliefs, cultural histories and world views they bring to the learning situation help in the way learners interact and interpret new ideas and events they encounter. Bruning, Schraw, Norby and Ronning (2004) also agree with this by indicating that with the constructivists' perspective of teaching and learning, "learners are active in constructing their own knowledge and that social interactions are important to knowledge construction" (p. 195). These reecho the relevance of focusing on the learner by creating a conducive environment regarding learners' experiences and prior knowledge, social and cultural interactions in addition to support from teachers for learners' knowledge construction.

Following constructivists' teaching and learning position, the standards-based curriculum emphasises that mathematics teaching and learning should be "pivoted on learner-centred approaches that engage learners physically and cognitively in the knowledge-acquiring process in a rich and rigorous inquiry-driven environment" (MOE, 2019, p.v). It is believed that teaching and learning effectiveness for the school curriculum for mathematics should be inquiry-based by following constructivist perspectives. In placing much emphasis on constructivists' standpoint, the standards-based mathematics curriculum emphasises that:

mathematics learning is an active contextualised process of constructing knowledge based on learners' experiences rather than acquiring it. Learners are information constructors who operate as researchers. Teachers serve as facilitators by providing the enabling environment that promotes the construction of learners' knowledge based on their previous experiences. This makes learning more relevant to learners and leads to the development of critical thinkers and problem solvers (MOE, 2019, p. v).

This is to make sure that learners develop the requisite values, attitudes, knowledge and skills for realising and achieving their full potential in life. This could contribute to the Ghanaian agenda of transforming social, economic and political issues. For this reason, the standards-based curriculum utilises flexible and innovative teaching, learner-centred pedagogies, appropriately differentiated strategies of teaching, multiple strategies of assessment, as well as a shift from the traditional teacher-centred pedagogies to dialogic teaching and learning approaches (NPECF, 2018). Similarly, using an inquiry-based approach to learning, engaging in independent projects, and utilising technology is highly emphasised for implementing the standards-based curriculum.

Therefore, the aims and objectives of the standards-based mathematics curriculum are purged to reflect constructivists' teaching and learning perspectives. For example, the mathematics curriculum aims to develop learners to become "mathematically literate, good problem solvers who are capable of thinking creatively and have both the confidence and competence to participate fully in the Ghanaian society as responsible local and global citizens" (MOE, 2019, p.v; NPECF, 2018, p.20). The specific objectives of the same

curriculum also indicate that learners develop “mathematical curiosity and use inductive and deductive reasoning when solving problems, develop abstract, logical and critical thinking and the ability to reflect critically upon their work and the work of others” (MOE, 2019, p. vi). All these demonstrate the strong attachment of the standards-based mathematics curriculum to constructivists’ teaching and learning perspectives.

Utilising constructivists’ teaching and learning approach helps to engage learners and make them reflective thinkers and problem solvers (Abrams & Lockard, 2004). For these reasons, a constructivist-based classroom learning environment is characterised by the active engagement of learners, problem-solving, group discussions and self-ownership of one's learning. Solomon (2000) further indicates that using the constructivists’ approach encourages collaboration, active exploration, respect for multiple views and the use of authentic problem-solving. Employing a constructivist approach also provides learners with a basis to bring fresh ideas to the classroom and allows teachers to activate learners’ learning through their prior knowledge and experiences (Major & Mangope, 2012). It makes learners discover and create opportunities for learners to debate and dialogue with their fellow learners and teachers (Laz & Shafei, 2014). It also promotes learners’ social interaction on which effective learning is anchored. In effect, the constructivist teaching and learning approach shifts teaching and learning attention from the traditional perspective where learners are passively engaged and teachers assume a leading role in the process of teaching and learning.

In line with these benefits, the demand for 21st century skills, meeting the demands of Sustainable Development Goal 4 (SDG 4) and the vision of

Ghanaian education for Agenda 2030, there was the need to ground the standards-based curriculum on constructivists' philosophy of teaching and learning.

Teachers' Knowledge and Curriculum Implementation

Curriculum implementation has been viewed from different lenses. However, most scholars believe that curriculum implementation is putting the intended or designed curriculum into actual classroom practice to achieve its purpose (Afangideh, 2009; Ibeh, 2022). Thus, translating curriculum expectations, rationale, philosophy, objectives, aims, goals, content, prescribed pedagogies, recommended assessment strategies and other relevant aspects of a curriculum into actual classroom practice. This could be done effectively taking into consideration the final implementer. As indicated in Rogan and Grayson's (2003) theoretical perspective on curriculum implementation, the teacher factor is indispensable when it comes to the capacity to innovate during curriculum implementation. Teachers' competency and knowledge to translate the intended curriculum into actual classroom practice are crucial.

Shulman (1986, 1987) provides the initial perspective into teachers' knowledge necessary for classroom instruction. Shulman categorises teachers' knowledge into "content knowledge, general pedagogical knowledge, curricular knowledge, pedagogical content knowledge (PCK), knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes and values, and their philosophical and historical grounds". For this study, as already indicated in the conceptual framework (see Figure 3, p. 34), attention is focused on teachers' content, pedagogical,

pedagogical content, and contextual knowledge about the standards-based mathematics curriculum.

Teachers' Content Knowledge and Curriculum Implementation

Different researchers use different terms and meanings to analyse content knowledge (Lucus, 2006). In some cases, content knowledge is subsumed into knowledge of subject matter, and in other cases, knowledge of subject matter and knowledge of content are used interchangeably. For instance, Bonney (2015) argues that knowledge of the subject matter is linked to knowledge of the content area and knowledge of curricula. It suggests that knowledge of content is linked to knowledge of subject matter. Hence, the two may be used interchangeably.

Shulman (1986) initially categorises knowledge of content among pedagogical content knowledge and knowledge of curricula as teacher knowledge needed for classroom practices. As explained by Shulman (1986), knowledge of content surpasses knowing “facts or concepts”. Shulman elaborates on two ways of comprehending knowledge of the subject matter teachers require for classroom practice. These are: “knowing that” and “knowing why”. The conception of “knowing that” is declarative knowledge which entails understanding a particular topic rules, algorithms, concepts and procedures. It represents substantial knowledge adequate for pedagogical content knowledge decisions (Even & Tirosh, 1995). On the other hand, the conception of “knowing why” is procedural knowledge, which entails understanding and knowing the meaning of “why” things exist in the manner in which they are. It is the knowledge that reinforces better pedagogical decisions

(Even & Tirosh, 1995). This suggests that teachers require both knowledge of the content of a subject and its structure (Shulman, 1986).

The early work of Schwab emphasises the structures of subject matter knowledge needed for classroom practices. These are: “substantive structures” and “syntactic structures”. Substantive structures are “conceptual devices which are used for defining, bounding and analysing the subject matter” (Schwab, 1978, p.246). It is the body of knowledge which is characterised by facts, ideas, theories and concepts about the subject matter. Thus, substantive structures relate to the organisation of concepts, facts, ideas, principles and theories about the subject matter (Shulman, 1986). Syntactic structures on the other hand deal with the “pathway by which discipline moves from raw data through a longer or shorter process of interpretation to its conclusion” (Schwab, 1964, p.14). Considering Shulman's (1986) and Wilson, Shulman and Richert's (1987) perspectives, it describes a means of assessing if a discipline is true or false, valid or invalid. It also entails a description of the way of obtaining knowledge about the subject matter, its methodology, and processes of the subject (Maguvhe, 2006).

Building on Shulman's (1986, 1987) initial work, the concept regarding knowledge of content has been expanded. For instance, Grossman (1990) conceptualises knowledge of subject matter as knowing “syntactic structures, content and substantive structures”. Again, Gilbert (2010) considers subject matter knowledge as a substantive component, a syntactic component and a beliefs component. Adding that each contributes to teachers' knowledge for effective teaching.

In addition, Ball, Thames and Phelps (2008) categorise knowledge of subject matter regarding mathematics into “common content knowledge, specialised content knowledge and horizon content knowledge”. Common content knowledge is applied to other professions such as accounting, marketing and finance. It is not exclusively unique to the teaching of mathematics (Ball et al., 2008). It also includes general knowledge of mathematics needed in everyday life. The specialised content knowledge is unique knowledge exclusively for the teaching of mathematics. Hill, Ball and Schilling (2008) indicate that specialised content knowledge enables “teachers to engage in particular teaching tasks, including how to accurately represent mathematical ideas, provide mathematical explanations for common rules and procedures, and examine and understand unusual solution methods to problems” (p. 377). This means that specialised content knowledge engages teachers to undertake tasks and activities that are purely for teaching mathematics subjects. For instance, assessing mathematics tasks, designing instruction for mathematics, creating and posing mathematical problems all require specialised knowledge. Hence, it differs from the common content knowledge which applies to other professions. Horizon content knowledge on the contrary, deals with understanding the relations among various mathematics concepts (Ball et al., 2008). It describes teachers’ understanding of how mathematical concepts connect with one another, how these concepts generate various topics and how structures of mathematics are built around topics (Koponen, Asikainen, Viholainen, & Hirvonen, 2017).

In the view of Even (1993), knowledge of subject matter is “knowledge and understanding of facts, concepts, and principles and the ways in which they

are organised, as well as knowledge about the discipline” (p.94). This suggests that knowledge of content may not always entail knowing facts and information but goes beyond that. Consistent with this, Ball (1988) highlights that knowledge of subject matter goes further than merely providing learners with facts and information. For this reason, teachers’ content knowledge in relation to this study is considered as teachers’ knowledge of the organisation and structure of the standards-based mathematics curriculum, expected learning behaviours, instructional expectations and core competencies (see the conceptual framework, figure 3, p. 34).

Teachers’ knowledge of content performs a critical role when it comes to teaching. It motivates teachers, sustains their interest and makes them have favourable attitudes towards the particular subject they teach (Barlow & Cates, 2006). It helps teachers to reduce learners’ misconceptions, misunderstandings and misinterpretations during instruction (Valanides, 2000a). Research has found better success in students’ performance with teachers who have sufficient knowledge of what they teach (Ademulegun, 2001). It is for these reasons that teachers are encouraged to have a comprehensive and sufficient understanding of subject matter knowledge (NCTM, 2000; Schmidt et al., 2009).

In line with this, pillar one of the National Teacher Education Curriculum Framework (NTECF, 2017) considers knowledge of subject matter and curricula as key for teachers of basic schools. It is believed that a holistic teacher education entails developing teachers’ professional values and attitudes, professional knowledge and professional practices (NTECF, 2017). In doing this, pillar one of the National Teacher Education Curriculum Framework (NTECF, 2017) requires that Initial Teacher Education (ITE) institutions in

Ghana prepare teachers to secure strong content knowledge and curricular knowledge for classroom instruction. According to the NTECF (2017), “for effective curriculum implementation, it is important that the teacher attains a subject knowledge that goes beyond what is contained within the curriculum at the level he/she is specialising” (p. 21). It is believed that a strong content knowledge of a teacher enables him/her to personally identify and address gaps in subject knowledge. Therefore, the National Teacher Education Curriculum Framework (2017) recommends that teachers acquire and demonstrate good content knowledge to support learners in producing successful learning outcomes.

As earlier indicated, teachers’ content knowledge about the standards-based mathematics curriculum is considered in terms of knowledge of the organisation and structure of the curriculum, expected learning behaviours, instructional expectations and core competencies (see the conceptual framework, figure 3, p. 34). Hence, the subsequent sections provide a review of these sub-dimensions or variables of teachers’ content knowledge about the standards-based mathematics curriculum.

Knowledge of Organisation and Structure of Curriculum

Knowledge of the organisation and structure of the curriculum is considered a sub-dimension or variable of teachers’ content knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Knowledge of how the curriculum is organised and structured is crucial since teachers employ curriculum materials when selecting content and learning experiences for mathematics delivery (Cai, Wang, Moyer, Wang,

& Nie, 2011). Hence, teachers ought to be knowledgeable and familiar with the organisation and structure of the standards-based mathematics curriculum.

Principally, the standards-based curriculum is organised and structured into key headings and annotations (MOE, 2019; NaCCA, 2019). It has “strands, sub-strands, content standards and learning indicators” explained in relation to a particular subject area. For instance, in the context of mathematics, strands constitute broad categories of mathematics content that should be learned. Content standard entails predefined “knowledge, skill and/or attitude” that a learner develops at a specific educational stage. Learning indicator highlights a distinct “outcome or milestone” learners must achieve every year to fulfil the requirements of the content standard. Exemplar includes “support and guidance”, as well as teaching and learning activities facilitators utilise for delivering the curriculum (MOE, 2019; NaCCA, 2019). Performance standards detail the level of performance learners are expected to achieve as enshrined in the content standards. These are accompanied by performance indicators. The indicators measure the performance against the stated learning targets (MOE, 2018). It provides the basis to determine whether a learner has met the performance standards.

The annotations make it easier to reference the curriculum by indicating the “class (grade level), strands, sub-strands, content standards and learning indicators” (NaCCA, 2019, p. xviii). That is, the annotations make the curriculum users easily identify the grade level, strand, sub-strand, content standard and learning indicator. Figure 4 illustrates an annotation of the new standards-based mathematics curriculum.

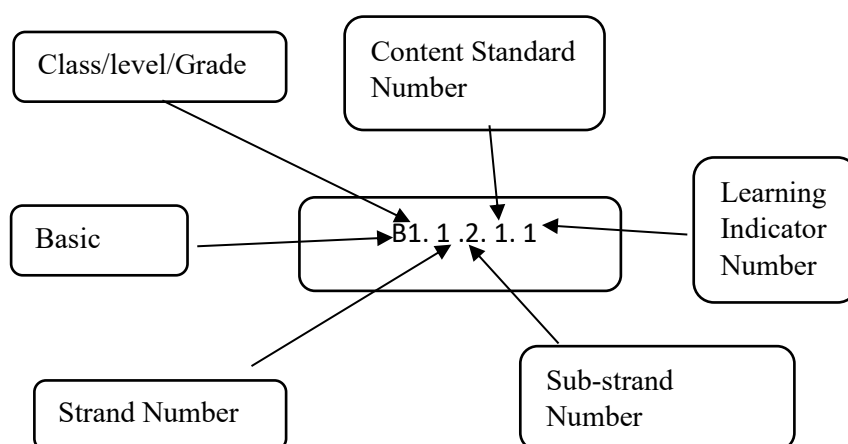


Figure 4: A unique annotation of the new standards-based curriculum

Source: Standards-Based Mathematics Curriculum B1 – B3

The annotation in Figure 4 indicates the class (level or grade), in this case, the basic one (B1). The next number which is 1 indicates the strand number, which is the broad idea or concept of content to be studied. The number 2 indicates the sub-strand number, which is the topic within each strand (broad areas or sections of content). The number 1 right after the 2 indicates the content standard number, which is the knowledge, skills or attitudes that a learner is expected to attain at each level of education. The last number (1) indicates the learning indicator, which is the outcome learners must exhibit to meet the expectations of the content standards. In other words, it indicates the demonstrable evidence of the attainment of the expectations of the content standards.

The organisation of the major strands of the lower primary standards-based mathematics curriculum includes numbers, algebra, geometry and measurement and data. The sub-strands for the various strands cut across the grade levels from Basic 1 to Basic 3. For instance, counting, representation and cardinality of numbers as a sub-strand cut across the grade levels from Basic one (B1) to Basic three (B3). This pertains to the remaining sub-strands of the lower primary standards-based mathematics curriculum. Similarly, the major

strands for the upper primary standards-based mathematics curriculum are numbers, algebra, geometry and measurement and handling data. The strands for the upper and lower primary curricula are the same. However, in terms of the sub-strands' scope, the upper primary mathematics curriculum differs slightly from the lower primary mathematics curriculum. For instance, the sub-strands for algebra are expanded to include functions and unknowns, expressions, equations and inequalities. In a similar vein, the sub-strands for geometry and measurement are expanded to include geometrical reasoning. Again, the sub-strands of data are expanded to the study of probability. The various sub-strands of the upper primary standards-based mathematics curriculum cut across Basic 4, Basic 5 and Basic 6.

For the Common Core Programme Mathematics Curriculum just like the lower and upper primary mathematics curricula, the organisation of major strands for Basic 7, Basic 8, Basic 9 and Basic 10 include numbers, algebra, geometry and measurement and handling data. Even though the same strands cut across all the grade levels from Basic one (B1) to Basic ten (B10), the sub-strands of the Common Core Programme Mathematics Curriculum are expanded to increase learners' conceptualisation of the major strands. For instance, the sub-strands for numbers are expanded to include ratios and proportions. This could broaden learners' understanding and scope of how numbers are manipulated in different ways. The sub-strands for geometry and measurement are also expanded to include construction and transformation. Teachers use curriculum materials to select content and learning experiences when teaching mathematics (Kilpatrick, 2003; Stein & Kaufman, 2010; Tarr,

McNaught, & Grouws, 2012). It suggests that teachers need to understand how the curriculum is organised and structured in order to align the curriculum.

Knowledge of Expected Learning Behaviours (Learning Domains)

Knowledge of expected learning behaviours is considered a sub-dimension or variable of teachers' content knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Principally, the new curriculum emphasises three main learning behaviours or domains: "knowledge, understanding and application, process skills, attitudes and values" (NaCCA, 2019, p. viii). As part of the knowledge, understanding and application domain, a facilitator is expected to engage learners in "knowing, understanding, applying, analysing, synthesising, evaluating, and creating" (NaCCA, 2019, p. viii). This is consistent with the revised version of Anderson and Krathwohl's (2001) taxonomy of instructional objectives, derived from the original Bloom's (1956) taxonomy of setting instructional objectives. At the higher level regarding learning behaviour, learners are expected to analyse issues and problems, and at a much higher level, combine knowledge by synthesising different concepts in addressing a problem. In addition, learners are expected to "evaluate, estimate and interpret" a given concept. At the highest level of learning behaviour in line with Anderson and Krathwohl's (2001) classification, learners are expected to "create, invent, compose, design and construct" from the numerous experiences they have acquired (NaCCA, 2019). This level constitutes higher-order thinking which in most cases is not given the needed attention (MOE, 2019; NaCCA, 2019).

The process skills are aligned with the psychomotor domain of learning which has been proposed in varied forms (Dave, 1975; Harrow, 1972; Simpson,

1972). According to Simpson (1972), it deals with coordinating, using “motor-skill areas” and engaging in physical movement. The standards-based mathematics curriculum emphasises developing process skills by engaging learners in skills which comprise “observing, clarifying, comparing, communicating, reporting, predicting, analysing, generalising, evaluating, designing, measuring and interpreting” (NaCCA, 2019, p. x). It is believed that learners are more likely to develop these process skills when exposed to mathematical situations that challenge them. This makes it possible for learners to develop a good attitude towards mathematics (MOE, 2019; NaCCA, 2019).

The attitudes and values aspect of the expected learning behaviours is also aligned with the affective domain. This domain is proposed by Krathwohl, Bloom and Masia (1964) as a means of setting objectives for instruction. According to Hoque (2016), this domain entails how individuals emotionally deal with issues in terms of their feelings, values, appreciation, enthusiasms, motivations and attitudes towards a particular issue or situation. It is believed that, for the Ghanaian learner to be a competent and reflective citizen to solve personal and societal problems, he/she needs to be equipped to develop good attitudes, values and psycho-social skills (MOE, 2019, NaCCA, 2019). This makes learners contribute and participate fully in debates concerning the nation’s social and economic development issues, themselves and others (MOE, 2019; NaCCA, 2019). For this reason, the standards-based mathematics curriculum recommends developing key attitudes including “commitment, tolerance, patriotism, flexibility in ideas, respect for evidence, comportment, reflection, cooperation, responsibility, environmental awareness and respect for the rule of law” (NaCCA, 2019, p. xii). Similarly, key values comprising

“respect, diversity, equity, commitment to excellence, teamwork, collaboration, truth and integrity” are emphasised in the standards-based mathematics curriculum.

Knowledge of Instructional Expectations

Knowledge of instructional expectations is considered a sub-dimension or variable of teachers’ content knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Expectations are viewed from different perspectives (Cooper & Good, 1983; Good, 1987; Rubie-Davies, 2014). However, in this context, expectations are what you are required to do. Therefore, instructional expectations are what teachers or facilitators are required to do in the process of teaching and learning to achieve curriculum aims, goals and aspirations. Every curriculum articulates what teachers are expected to do in the process of teaching and learning. Similarly, the standards-based mathematics curriculum outlines certain instructional expectations. Among others, teachers are required to assist learners’ learning by creating classroom discourse that makes them take responsibility for their learning (MOE, 2019; NaCCA, 2019). Also, mathematics content, teaching and learning activities are to be arranged to meet learners’ background experiences, interests and ability levels. Similarly, multiple approaches and strategies are required to address learners’ diverse learning needs (NaCCA, 2019). Learners are also expected to work together as colleagues and develop communities of mathematics learners who demonstrate mathematical inquiry skills, while teachers serve as facilitators and guides (NaCCA, 2019).

Knowledge of teachers regarding curriculum expectations is crucial since teachers with different expectations tend to have different instructional practices (Rubie-Davies, 2014). Research has also shown that teachers with high expectations contribute to students' success and employ more effective teaching practices compared to teachers with low expectations (Rubie-Davies, 2007; Rubie-Davies, Peterson, Sibley & Rosenthal, 2015; Weinstein, 2002). Consistent with this, Papageorge, Gershenson and Kang (2020) and Wu and Bai (2015) also indicate the effects of teachers' expectations on students' academic attainment. It further suggested that when teachers are well informed about what ought to be implemented, it could influence learners' attainment of instructional goals.

Knowledge of Core Competencies

Knowledge of core competencies is considered a sub-dimension or variable of teachers' content knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Core competencies imply various things to various people. For instance, from a business perspective, Prahalad and Hamel (1990) attribute the construct to a firm's capacity to collectively learn, use various skills, and technologies to deliver better results or value which is uniquely attributed to the organisation. Others describe core competencies to include capabilities, knowledge, skills, and expertise (Torkkeli & Tuominen, 2002), sufficient integration of knowledge, technology, resources, techniques and skills (Yang, 2015).

However, regarding this study, core competencies constitute a body of knowledge, skills, attitudes and values that subject teachers (e.g. mathematics teachers) need to develop in their learners at all levels to make learners draw

upon it for lifelong learning, living and working (MOE, 2019; NaCCA, 2019; NPECF, 2018). In teaching and learning mathematics, they serve as how learners and teachers interact with the subject matter (MOE, 2019; NaCCA, 2019). These core competencies enhance learners' abilities and how they think about what to do. For the Ghanaian child to contribute to the 21st-century world, the standards-based mathematics curriculum emphasises developing core competencies related to “critical thinking and problem-solving, creativity and innovation, communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy” in the process of teaching and learning (NaCCA, 2019).

Critical thinking and problem-solving competencies entail engaging learners to develop their reasoning and cognitive skills to apply, analyse and address issues. By developing these skills, learners employ their experiences to examine situations and select the best possible options to deal with the problems at hand. This contributes to their ability to take responsibility for their learning (MOE, 2019; NaCCA, 2019). Creativity and innovation competencies involve inculcating in learners the skills of coming up with novel approaches for addressing problems and employing technologies as well as other advanced tools in dealing with problems at hand (MOE, 2019; NaCCA, 2019). It encompasses creating new ideas and methods which consequently make learners independent thinkers (MOE, 2019; NaCCA, 2019).

Communication and collaboration competencies entail developing learners' skills in using texts, symbols and languages to acquire information concerning their experiences in life. It also entails engaging learners to share their ideas, dialoguing with others by listening and learning from them, as well

as accepting the views of others (MOE, 2019; NaCCA, 2019; NPECF, 2018). Cultural identity and global citizenship competencies highlight the spirit of putting the country first in all things learners do, as well as accepting what it means to be a Ghanaian (MOE, 2019; NaCCA, 2019; NPECF, 2018). Also, learners are expected to develop a sense of awareness about Ghanaian socio-economic development in order to contribute to it and the global community at large (MOE, 2019; NaCCA, 2019; NPECF, 2018). Again, learners are expected to develop a skill in analysing cultural and global trends.

Personal development and leadership competencies deal with developing learners' skills in self-awareness and self-esteem by helping learners identify and develop their talents and aspirations (MOE, 2019; NaCCA, 2019; NPECF, 2018). It also requires developing learners to demonstrate honesty, as well as showing concern for others' well-being. The development of these skills enables learners to distinguish what is good and bad and show "perseverance, resilience and self-confidence", which enables them to take a leadership role and other responsibilities (MOE, 2019; NaCCA, 2019; NPECF, 2018). Digital literacy competency entails developing learners' skills of discovering, acquiring and communicating through ICT, as well as using digital media responsibly to improve their learning (MOE, 2019; NaCCA, 2019; NPECF, 2018).

Developing learners' skills in these core competencies is of great importance. For instance, problem-solving develops learners' understanding by evoking their thinking and reasoning about mathematical ideas and also positions them to connect new ideas to already learned materials (Schoen & Charles, 2003). Developing skills of learners in problem-solving also provides them with the opportunity to apply them for lifelong learning (Cobb & Hodge,

2002). Similarly, Soland, Hamilton and Stecher (2014) discovered that developing critical thinking improves understanding of academic content and later career performance. Yusuf (2005) is of the view that knowledge of digital literacy influences learners' teaching and learning in general.

Teachers' Pedagogical Knowledge and Curriculum Implementation

The two constructs, general pedagogical knowledge and pedagogical knowledge, denote different things for different people. Shulman (1986, 1987) describes general pedagogical knowledge as knowledge of "broad principles and strategies of classroom management and organisation" for the effective delivery of cross-curricular instruction. This conception is expanded by other researchers due to the belief that it is limited in scope. For instance, Carlsen (1999) and Grossman (1990) conceptualise general pedagogical knowledge to include knowledge of learning and learners, classroom management, curriculum, instruction and others. Morine-Dersheimer and Kent (1999) see general pedagogical knowledge in terms of understanding management and organisation in the classroom, appreciating strategies and models for instruction, reflection, and communication and discourse in the classroom. Fernandez (2014) refers to the same construct (general pedagogical knowledge) as knowledge of the purposes and values of education, cognitive, social and developmental theories of learning, including how one applies these in classroom situations. It is also seen as the "principles and strategies of classroom management and organisation, teaching methods, assessment, learning processes and learner characteristics that are cross-curriculum" (NTECF, 2017, p. 28).

On the other hand, Guerriero (2017) considers pedagogical knowledge as teachers' specialised cognitive knowledge for establishing an effective learning and teaching environment to benefit every learner. Similarly, pedagogical knowledge includes knowledge of "approaches, methods, strategies, appropriate relevant teaching and learning resources for ensuring that every learner benefits from the teaching and learning process" (MOE, 2019, p. xv; NaCCA, 2019, p. xv). It is the knowledge needed for teaching across a range of subject areas.

Notwithstanding these perspectives, both constructs are sometimes used interchangeably. For instance, pedagogical knowledge is considered to be composed of general pedagogical knowledge (NTECF, 2017). In a similar vein, Mulholland (2014) posits that general pedagogical knowledge is just used as a synonym to describe knowledge and skills needed to teach generally so that it can be differentiated from the knowledge and skills needed to teach a particular subject area. This suggests that both constructs may be used interchangeably.

Teachers' pedagogical knowledge is essentially useful in the process of teaching and learning. Due to the important nature of teachers' pedagogical knowledge, it is considered one of the major pillars of knowledge for teachers of basic schools (NTECF, 2017). It provides a basis for teachers to appreciate instructional principles generally, theories of learning, educational philosophies, and the needed support for effective teaching and learning (NTECF, 2017). Atjonen, Korkeakoski and Mehtalainen (2011) are of the view that profound teachers' pedagogical knowledge leads to successful teaching and learning. Also, teachers' pedagogical knowledge ensures teachers' teaching efficacy, allowing flexibility in the process of teaching and learning, and

adjusting instruction to accommodate learners' diverse needs (Hativa, Barak & Simhi, 2001; McAlpine, Weston, Beauchamp, Wiseman, & Beauchamp, 1999).

Other studies indicate that teachers' pedagogical knowledge contributes to a better understanding of learners in the teaching and learning process (Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). This is because teachers with high pedagogical knowledge can engage learners, sustain their interest and attention, and make them focus as well (Dwyer & Schachter, 2020; Nganga, 2020). In line with this, some researchers argue that effective classroom teaching and learning are dependent on teachers' good knowledge of pedagogy (Clements & Sarama, 2008; Oakley, 2020; Stipek, 2004).

Making learners benefit from classroom instruction, the pedagogical approaches adopted by teachers count. It suggests that teachers need to utilise effective pedagogical approaches to meet the demands and expectations of the 21st-century learner. In line with this, standards-based mathematics recommends pedagogical approaches which comprise learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, and application of ICT for effective learning and teaching (MOE, 2019; NaCCA, 2019; NPECF, 2018).

Therefore, this study considers teachers' pedagogical knowledge about the standards-based mathematics curriculum with reference to teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, and ICT as a pedagogical tool (see the conceptual framework, figure 3, p. 34). Hence, the subsequent sections provide a review of these sub-dimensions or variables of teachers' pedagogical knowledge about the standards-based mathematics curriculum.

Knowledge of Learner-Centred Pedagogy

Learner-centred pedagogy is considered a sub-dimension or variable of teachers' pedagogical knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Learner-centred pedagogy is viewed from different angles and perspectives by different authorities. For instance, Manqele (2017) summarises learner-centred pedagogy as a pedagogy that encompasses the active role of a learner in the process of learning, utilises multiple strategies of teaching, resources and representations to satisfy diverse learners' needs, and shifts teachers' roles from merely passing information to facilitating learners' learning. Black (2007) also characterises learner-centred pedagogy as a pedagogy that gives autonomy to learners, learners have control over their learning, and teachers are flexible and responsive to learners' needs, knowledge and interests. The author further indicates that learner-centred pedagogy is based on using authentic tasks, emphasising meaning and understanding, ensuring how to cooperate, communicate and negotiate with learners as well as connecting learning to their community.

In agreement, Weiner (2002) is of the view that learner-centred pedagogy emphasises collaboration and provides the basis for learners to reflect on what they learn. Learner-centred pedagogy is grounded on constructivists' perspectives of teaching and learning. To the constructivists, individuals construct their meaning from new and prior experiences (Jonassen, 1991). A curriculum that is grounded on this philosophy provides the opportunity for learners to construct their meaning and understanding. As indicated in the National Pre-tertiary Education Curriculum Framework (NPECF, 2018),

principally, the standards-based curriculum emphasises learners' knowledge constructions which epitomise the constructivists' standpoint.

The standards-based curriculum recommends putting learners at the core of the teaching and learning process and offering essential experiences for learning to ensure effective progression as well as efficient knowledge construction (MOE, 2019; NaCCA, 2019). To consolidate learners' gains in the process of teaching and learning, the standards-based mathematics curriculum recommends meaningful hands-on activities, discussion of ideas, solving problems in groups, active engagement and taking ownership of learning (MOE, 2019; NaCCA, 2019).

Therefore, the teacher's role in this is to facilitate, and establish a safe environment for learning where every learner is welcomed, help learners to connect with different information sources in multiple ways, link problems to a practical context to provide a learning opportunity and engage learners in problem-solving and collaborative learning (MOE, 2019; NaCCA, 2019). Again, teachers are to engage learners using inquiry-based learning, experiential learning, participative learning, cooperative learning and classroom discussion (Weiner, 2002), to enhance learners' learning.

Incorporating learner-centred pedagogy in classroom situations is beneficial. For instance, Brown (2003) reports that it provides the basis for teachers to satisfy learners' diverse preferences. This is because classroom teachers have the opportunity to utilise multiple learning strategies and varied experiences of learners, making learners unlimited in their scope. Also, findings indicate that engaging learners in learner-centred pedagogy contributes to gains in academic achievement (AY Emanet & Kezer, 2021; Nolan & McKinnon,

2003; Vars, 1997). Similarly, Brough and Calder (2012) discovered that learners become highly motivated and engaged with a conceptual understanding of mathematics when they practice student-centred inquiry learning. Engaging learners in learner-centred pedagogy increases their confidence and promotes positive behaviours (Burns, Pierson, & Reddy, 2014). This suggests that engaging learners in learner-centred pedagogy contributes to classroom success.

Knowledge of Inclusion and Equity Pedagogy

Knowledge of inclusion and equity pedagogy is considered a sub-dimension or variable of teachers' pedagogical knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Inclusion and equity pedagogy are viewed from different perspectives. However, Ainscow (2020) notes that, internationally, it is increasingly accepted as a kind of pedagogy that supports and welcomes the diversity of all learners. Thus, a pedagogy that is responsive to learners' diversity in terms of race, social class, ethnicity, gender, and ability, among others to make sure that the process of teaching and learning benefits every learner. Its emphasis is to ensure fairness to all learners (Ainscow, 2020). Inclusion and equity education assume that every learner has a right to education (Ainscow, 2020). This is consistent with the Human Rights Universal Declaration of 1948, the Convention against Discrimination in Education of 1960 of the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), and the Children's Rights Convention of 1990, which agree that all humans have the right to education (Mugambi, 2017).

As explained by Florian (2014), inclusive pedagogy should support all learners and teachers should create an environment and select instructional

approaches that are advantageous to all learners in the classroom. In addition, Ainscow et al. (2006) are of the view that in adopting this strategy, steps should be taken to remove all barriers so as to ensure the participation and achievement of all learners in the classroom. Similarly, teachers should design learning experiences in line with the Universal Design of Learning (UDL) that cater for all learners (Livingston-Galloway & Robinson-Neal, 2021).

In line with this, the standards-based mathematics curriculum emphasises inclusion and equity pedagogy. As indicated in the National Pre-tertiary Education Curriculum Framework (NPECF, 2018), “the right of every child is to have equal access to quality education” (p. 23). The framework stresses addressing learners’ diversity and special needs by using a variety of approaches in the learning process, recognising individual learner needs, learning styles, learning experiences and motivational levels in the learning process (NPECF, 2018). Also, the framework recommends that learning is linked to learners’ abilities, interests, potential and background experiences.

The role of inclusion and equity pedagogy is enormous. It provides the basis to reduce inequality in learners' learning, pays attention to learners' needs, provides support for learners' learning, and gives consideration to learners’ diversity (Florian, 2010, 2015). Utilising this pedagogy makes it possible to acknowledge students’ differences as strengths and resources for effective engagement for students’ potential learning (Florian, 2010). Again, Florian and Black-Hawkins (2011) maintain that it increases students’ participation in the process of teaching and learning and reduces exclusion. Alemayehu (2020) sees it as a key pedagogy for teachers to provide meaningful teaching and learning and create opportunities suitable for learning. In addition, it enhances students’

development in terms of psychosocial and academic whether such learners have special needs for education or not (Loreman, Deppeler & Harvey, 2005; Tirussew, 2005).

The National Teacher Education Curriculum Framework (NTECF, 2017) emphasises that, as part of providing the enabling environment to ensure every learner accesses the best opportunity for learning, the teacher factor is crucial. Teacher education institutions in Ghana are encouraged to review their programmes to reflect inclusive education and train teachers to develop the needed knowledge and skills to “understand how to recognise and address barriers to learning and how to plan for diversity” (NTECF, 2017, p. 41). Further, teachers are to be “trained to develop professional capacities to focus on the diverse characteristics of the individual learner(s)” to provide instruction that reflects “equity and inclusivity” (NTECF, 2017, p. 41). Again, teachers are to be equipped to appreciate the cultural and socio-linguistic diversities and dynamics that operate in the classroom, to foster proper equity and inclusivity (NTECF, 2017).

Knowledge of Differentiation and Scaffolding Pedagogy

Knowledge of differentiation and scaffolding pedagogy is considered a sub-dimension or variable of teachers’ pedagogical knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Differentiated pedagogy means different things to different people. However, a common agreement is that it is a pedagogical approach where instruction in the classroom is customised to learners’ diverse needs (Tomlinson, 1999, 2003, 2014; Tomlinson & Allan, 2000). That is, modifying or adjusting instruction by recognising differences among learners during

classroom instruction. In the view of Tomlinson (2014), it is the teachers' means of responding to learners' diverse needs. Since the classroom situation is made up of learners of different backgrounds, learning abilities, readiness levels, and other needs, teachers' instruction should be organised such that the process of teaching and learning favours every learner (Tomlinson, 2005).

This vision is not different from the pedagogical approaches of the new standards-based curriculum. As indicated by MOE (2019) and NaCCA (2019), the standards-based curriculum seeks to provide instruction that takes into consideration learners' differences such as learning styles, interests and readiness to accommodate learners for equal opportunity of learning. In light of this, it is recommended that teachers ensure that "each learner benefits adequately from the delivery of the curriculum" (NaCCA, 2019, p. xvi). To execute this, teachers need to differentiate "content, tasks, questions, outcome, groupings and support" (NaCCA, 2019, p. xvi).

Tomlinson and Eidson (2003) propose that instruction could be differentiated in terms of "content, process, product, affect and learning environment". Content deals with "facts, concepts, generalisations or principles, attitudes and skills related to the subject as well as materials that represent those elements" (Tomlinson & Allan, 2000, p. 7). Tomlinson and Imbeau (2010) are of the view that content needs to be presented to learners in several ways. To them, content may be differentiated by modifying it for some students and in some cases, advanced students may be allowed to move ahead of the class. Similarly, students may work independently on more complex issues (Tomlinson & Eidson, 2003).

As explained by Tomlinson and Imbeau (2010), the process entails “how students come to understand and make sense of the content” (p.15). It includes activities that teachers design to ensure that students make sense of the content. These activities could be in different forms aimed at helping the learners to have varied perspectives of the topic or the content. Thus, an instructional process could be varied to provide multiple perspectives for the learners.

Product, according to Tomlinson and Imbeau (2010), “demonstrates what students have come to know, understand and be able to do after an extended period of learning” (p.15). Tomlinson further indicates that a product is synonymous with an authentic assessment. That is, using a variety of means to assess students’ learning. It suggests that there should be several alternative ways students may employ to prove their understanding of a concept. The ultimate role is that teachers should provide an environment that promotes student choice (Tomlinson, 1999).

Affect deals with differentiating learning by attending to learners’ emotions and feelings. That is, modifying or adjusting instruction to accommodate learners’ varied emotional needs. Tomlinson and Strickland (2005) point out that students come to learning situations with varied academic capabilities and needs, and to promote learners’ success in this regard, their academic needs and emotions ought to be considered. Teachers need to ensure that they value students to create a room for students to feel part of the learning process.

The learning environment may be differentiated by ensuring that it is conducive to teaching and learning. It should be a setting where students and teachers collaborate. Robison (2004) maintains that a classroom environment

for learning should be planned and organised to address learners' varied needs. It should be a flexible environment, and the teachers' role is to engage learners in the decision-making process as well as create a practical environment for learning (Tomlinson & Strickland, 2005). To advance teaching and learning, the environment for learning should be modified to benefit all learners.

In differentiating "content, process, product, affect and learning environment", Tomlinson (2003) maintains that learners' readiness, interest, and learning profile need consideration (Tomlinson, 2003). According to Tomlinson and Imbeau (2010), interest is "that which engages the attention, curiosity, and involvement of a student" (p. 16). When learners are interested in the process of teaching and learning, it motivates and increases their engagement and concentration. Tomlinson and Eidson (2003) are of the view that the purpose of differentiating interest pertains to assisting learners in making connections among understanding, skills, and fresh information. This connection makes things appealing, relevant and worthwhile to the learner.

On readiness, Tomlinson and Imbeau (2010) see it as "student's current proximity to specified knowledge, understanding and skills" (p. 16). Teachers need to consider how to differentiate instruction based on their students' readiness. Doing this helps to tailor instruction to meet students' academic needs (Robison, 2004). According to Tomlinson and Eidson (2003), the aim of differentiating readiness entails presenting a concept that is a bit challenging at a certain point in time of students' growth and then offering the support needed to succeed in a new challenge. That is, students may be presented with a concept that is less difficult to do and progressively increase the sophistication with the needed support.

On learning profile, Tomlinson (2003) maintains that, is a means through which students process learning. It is also “a preference for taking in, exploring or expressing content” (Tomlinson & Imbeau, 2010, p. 17). That is how students understand the content they are supposed to learn. These are influenced by students’ learning styles, intelligence preferences, gender and culture (Gardner, 1993, 1999; Sternberg, 1997). Gardner suggests “logical-mathematical, linguistic, spatial, musical, bodily-kinesthetic, interpersonal and intrapersonal” as forms of intelligence preference for learning or thinking. In addition, the learning styles of learners could be a visual, auditory or kinesthetic preference. In the same vein, students come from different home backgrounds with different cultural orientations. Hence, teachers’ instruction should be differentiated in line with students’ learning styles, intelligence preferences, gender and culture to accommodate learners’ varied needs in a classroom learning environment. In the view of Tomlinson and Eidson (2003), “the goal of learning profile differentiation is to assist students to learn in the ways they learn best and to extend the ways in which they can learn effectively” (p. 4).

Equally, to ensure the effective delivery of the standards-based mathematics curriculum, teachers are expected to engage learners in effective scaffolding. That is the kind of support or assistance given to learners at their “Zone of Proximal Development” (ZPD). In the view of Taber (2018), “ZPD is the capacities somewhat beyond current competence but where success is possible with some support” (p. 6). The support could come from an expert (i.e. teacher), a more knowledgeable individual, collaborating with other learners, or an internalised practice (Walqui, 2006). Scaffolding is influential and considered a teaching strategy grounded on the ideas of ZPD (Taber, 2018),

which is traced to the work of Vygotsky. As indicated by NaCCA (2019), in scaffolding, “a variety of instructional techniques are used to move learners progressively towards stronger understanding and ultimately greater independence in the learning process” (p. xvii).

Teachers’ role in scaffolding learners’ learning is paramount. The standards-based mathematics curriculum recommends that teachers break learning tasks, experiences or concepts into smaller parts (NaCCA, 2019). Also, teachers are encouraged to provide learners with a reduced lesson and progressively increase the complexity as time goes on. Again, teachers are to provide learners with learning goals, illustrate concepts or problems in multiple ways, provide lesson vocabulary and exemplars, and build new lessons on learners’ previous knowledge and skills (NaCCA, 2019). Tomlinson and Eidson (2003) suggest that teachers should incorporate more scaffolding to enhance students’ learning. In the sense that students differ from one another regarding readiness, interests and learning profile (Tomlinson & Eidson, 2003).

The role of differentiation and scaffolding pedagogy is enormous. It is a means to embrace heterogeneous grouping (Marks, Woolcott & Markopoulos, 2021). That is a pedagogical approach that makes it possible to cater for learners of diverse backgrounds and learning abilities. It offers a positive learning environment based on diversity for individual learning growth where instruction is tailored to students’ ability, interest and readiness levels (Tomlinson, 1999). In this case, it becomes possible to address the needs of learners with varied learning abilities. Similarly, mediating learners’ learning through appropriate scaffolding strategies enhances classroom interaction (LaScotte, 2018), fosters learners’ collaboration (Rojas-Drummond & Mercer, 2003), reduce classroom

anxiety and increases willingness to communicate (Alavi & Esmaeilifard, 2021).

Knowledge of ICT as a Pedagogical Tool

Knowledge of Information and Communications Technology (ICT) is considered a sub-dimension or variable of teachers' pedagogical knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). ICT as a pedagogical tool entails utilising ICT and its accessories in the process of teaching and learning to solve problems including enhancing students' abilities (Jonassen, Howland, Marra, & Crismond, 2008). Thus, the ability to integrate ICT in the teaching and learning process to create solutions, access information, analyse and apply knowledge (Ndibalema, 2014). For instance, teachers' ability to improve classroom teaching and learning by utilising ICT-based activities involving blended learning, e-learning, computer-assisted learning, learning platforms, and virtual learning environments. Integrating ICT has increasingly influenced education, teaching and learning (Yusuf, 2005). Hence, all over the world, it is considered a key pedagogical tool for effective instruction.

The standards-based curriculum emphasises the application of ICT (NPECF, 2018). The new curriculum is “designed to use ICT as a teaching and learning tool to enhance deep and independent learning” (NaCCA, 2019, p. xvii). One expectation of the standards-based curriculum is teachers' ability to utilise ICT tools such as the “internet, calculators, radios, cameras, phones, television sets, computers and related software like Microsoft Office Packages (Word, PowerPoint, Excel)” and other multimedia to promote learning and teaching (NaCCA, 2019). ICT as a pedagogical tool has the potential to increase

students' opportunities for enhancing their innovation and deepening skills (NaCCA, 2019). It also allows students to obtain a lot of information online as well as offline. Similarly, learners get motivated and engaged by relating their learning experiences as well as offering them the opportunity to fit into the working world. Again, it allows students to organise and edit information in a variety of formats, build their confidence, increase their ability to apply ICT, as well as enhance their competence both present and in later years (NaCCA, 2019).

As a result of the aforementioned gains, it is expected that the classroom teacher is knowledgeable in integrating ICT into the process of teaching and learning. Building on Shulman's (1986, 1987) pedagogical content knowledge (PCK) for teaching effectively, Mishra and Koehler (2005) argue that to effectively integrate technology in the classroom, one needs to have technological pedagogical content knowledge. That is understanding how to utilise different technologies to teach, illustrate and promote the creation of knowledge for a particular subject content (Chai, Koh, & Tsai, 2013; as cited in Mailizar & Fan, 2020). Mishra and Koehler (2006) maintain that teachers should be knowledgeable and skilful in integrating ICT during teaching and learning. In a similar view, Albirini (2006) believes that the higher the knowledge of teachers in technology, the more likely they are to apply technology in the classroom.

Consistent with this, the National Teacher Education Curriculum Framework (NTECF, 2017) emphasises the crucial nature of teachers' professional knowledge regarding ICT integration into the process of teaching and learning. Teachers in Ghana are expected to equip themselves with the

requisite skills and knowledge as well as how to equitably, effectively and appropriately integrate ICT into the process of teaching and learning (NTECF, 2017). It is believed that sharpening the knowledge of teachers about ICT integration enhances their pedagogical transformation for deep learning (NTECF, 2017).

Teachers' Pedagogical Content Knowledge and Curriculum Implementation

Pedagogical content knowledge (PCK) means different things to different authorities. Fernandez (2014) argues that agreement on what constitutes PCK remains unresolved and that various researchers have proposed different models and concepts to depict PCK. Similarly, the analysis of Al-Jaro, Asmawi and Hasim (2017) on what constitutes pedagogical content knowledge further demonstrates that the issues of PCK components remain unresolved and people look at it from different perspectives. Shulman (1986) introduces the pedagogical content knowledge concept. In the view of Shulman (1986), PCK is a “most useful form of representation of ideas, most powerful analogies, illustrations, examples, explanations and demonstrations” (p. 9).

Also, Shulman indicates that it is the means of “representing and formulating” a subject in such a way that it becomes “comprehensible to others”. Again, Shulman (1986) points out that PCK constitutes one “understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning” (p. 9). It represents a unique combination of both the subject’s content and pedagogy (Shulman, 1986). It encompasses a unique type of knowledge used to blend a particular content and

its pedagogy to make learners construct their knowledge effectively in a particular context (Cochran, DeRuiter & King, 1993). To Shulman, PCK is a “missing paradigm” in the teaching environment.

Building on Shulman’s initial ideas of PCK, other authorities have expanded the PCK conceptualisation. For instance, Grossman (1990) considers PCK knowledge as conceptions of purpose for engaging a subject matter, knowledge of students’ understanding, curriculum and instructional strategies. Grossman's conceptualisation brings to bear the interactions of PCK and various categories of knowledge such as subject matter knowledge, pedagogical and contextual knowledge. Carlsen’s (1999) conceptualisation shows that PCK is made up of knowledge of students’ misconceptions, instructional strategies, curriculum, and teaching purposes, being influenced by general pedagogical and subject matter knowledge in a particular context.

From the perspective of Magnusson, Krajcik and Borko (1999), PCK for effective science instruction constitutes knowledge of teaching orientation, curriculum, students’ understanding, assessment, and strategies for instruction. In a similar vein, Park and Oliver (2008) postulate that for effective science instruction, PCK constitutes knowledge of teaching orientation, assessment, curriculum, students’ learning, strategies for instruction, and teacher efficacy as well as knowledge of reflection. Additionally, Abell (2008) considers PCK regarding science as knowledge of teaching orientation, curriculum, learners, assessment, and instruction, being influenced by pedagogical, contextual and subject matter knowledge.

These views suggest that the knowledge of teachers concerning pedagogical content knowledge is crucial for instruction. As indicated in the

National Teacher Education Curriculum Framework (NTECF, 2017), teachers' PCK knowledge provides a basis for teachers to understand and establish links between subjects and their pedagogical approaches as well as learners and the learning context. Similarly, teachers with high knowledge of pedagogical content knowledge create a supportive learning environment by responding to learners' needs (Baumert et al., 2010). Evidence suggests that teachers' knowledge of PCK has a link with quality classroom instruction as well as improvement in students' learning outcomes (Baumert et al., 2010; Griffin, Jitendra & League, 2009). Hence, the need for considering teachers' knowledge of PCK.

Therefore, building on Shulman's position and other positions (Abell, 2008; Park & Oliver, 2008; Magnusson et al., 1999), this study considers teachers' PCK about the standards-based mathematics curriculum as knowledge of learners' learning and assessment practices (see the conceptual framework, figure 3, p. 34). Hence, the subsequent sections provide a review of these sub-dimensions or variables of pedagogical content knowledge (PCK) of teachers about the standards-based mathematics curriculum.

Knowledge of Learners' Learning

Knowledge of learners' learning is considered a sub-dimension or variable of teachers' pedagogical content (PCK) about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Drawing from Shulman's (1986) pedagogical content knowledge (PCK), knowledge of learners' understanding or learning entails awareness of students' conceptions and preconceptions that they bring to the learning situation. In the view of Park and Oliver (2008), knowledge of learners' understanding or

learning deals with one's knowledge of students' misconceptions, learning difficulties, motivation and interest as well as knowledge of students' learning needs. Consistent with this, Magnusson, Krajcik and Borko (1999) opine that to understand students' learning, one needs to know areas of students' learning difficulties as well as knowledge of learning requirements.

Students' misconceptions, prior knowledge, thinking and beliefs influence their learning. According to Mohyuddin and Khalil (2016), learners' misconceptions interfere with the learning process when they start interpreting new experiences they encounter using such misconceptions. The reason is that students have high emotions and intellectual attachment to misconceptions, and due to this, they struggle to embrace new concepts unknown since they conflict with already existing misconceptions (Mohyuddin & Khalil, 2016). Verkade et al. (2017) are of the view that anticipating and identifying such misconceptions is a step in enhancing students' learning. This suggests that teachers' ability to anticipate learners' misunderstanding and misinterpretation of a concept is a crucial tool for understanding students' learning. In a similar vein, Dochy, De Rijdt and Dyck (2002) point out that prior knowledge influences new learning. Hence, activating it in the process of teaching and learning promotes understanding. In addition, the beliefs of students depict how they perceive knowledge and how it is gained (Schommer-Aikins, Unruh & Morpew, 2015). For instance, students who believe in the active construction of knowledge adopt effective strategies (Hao, Barnes, Branch & Wright, 2017) and this inures to their learning outcomes (Çevik, 2015). This suggests that teachers need to have an appreciation of students' misconceptions, prior knowledge, thinking and beliefs to understand their learning appropriately.

This is consistent with the tenets of the standards-based curriculum. As emphasised in the standards-based curriculum, teachers are to align content and learning experiences to learners' interests, abilities and experiences (NaCCA, 2019). Doing this presents teachers with opportunities to appreciate learners' frame of understanding. Learners create new ideas from prior experiences (NaCCA, 2019). Therefore, teachers' knowledge of learners' prior experiences, thinking and misconceptions provides the means for understanding their learning.

Knowledge of Assessment Practices

Knowledge of assessment practices is considered a sub-dimension or variable of pedagogical content knowledge (PCK) of teachers about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). The concept of assessment implies various things for people in different settings. However, in connection with education, assessment entails the process of gathering and interpreting information to make a decision about the learner, curriculum, programmes and other educational policies (NPECF, 2018). As indicated by NaCCA (2019), in the classroom situation, an assessment is conducted to collect information about the learner, and such information is evaluated to inform teachers' decisions for improving and promoting the learning of learners. Similarly, it is used for ascertaining the weaknesses and strengths of learners to help design instruction effectively for learners (NaCCA, 2019).

Different forms of assessment exist in the teaching and learning process with different purposes. As indicated by NaCCA (2019), assessing learners is either summative or formative. The formative assessment comprises

“assessment for learning and assessment as learning”. Assessment as learning is self-assessment where learners engage in self-reflection of their learning. It provides a basis for learners to own their learning and provides teachers with valuable information to refine strategies for teaching and learning (NaCCA, 2019). Assessment for learning occurs through the process of teaching and learning. Such information offers immediate feedback to amend teachers' strategies for teaching which enhances the learning progress of learners (NaCCA, 2019). On the other hand, summative assessment covers assessment of learning. As summarised by NaCCA (2019), an assessment of learning is done to assess the progress of learners' learning over time. Such information is communicated to students, their parents and other relevant parties (Poth, 2012).

It suggests that the 21st-century teacher needs to engage learners in meaningful and authentic assessment to unearth all the learning progress of their learners. According to Lund (1997), an assessment is considered authentic when it offers learners multiple opportunities to demonstrate their competencies. That is, using a variety of assessment methods (such as projects, diary, peer assessment, self-assessment and portfolios) in a classroom situation to assess learners' learning progress (Acar-Erdol & Yildizh, 2018).

The National Pre-tertiary Education Curriculum Framework (NPECF, 2018) recommends that assessment under the standards-based curriculum should engage learners to learn, and teachers are to do this by engaging learners in cognitive, affective and psychomotor domains of learning. Hence, authentic assessment methods such as learner observation, anecdotal records, interviews, portfolios and projects need to be utilised (NPECF, 2018). This provides a basis

for learners to use their “cognitive, aesthetic, physical and social potentials” (NPECF, 2018, p. 40), and also engages them in all facets of their lives.

This suggests that teachers’ knowledge of assessment practices in the classroom situation is crucial. As indicated in the National Teacher Education Curriculum Framework (NTECF, 2017), Ghanaian teachers are supposed to be knowledgeable about practices for assessment and be able to adopt appropriate assessment strategies. Similarly, they need to be knowledgeable in how to apply sound principles and procedures of assessment, as well as be conversant with the fundamentals of assessment in terms of its utilisation for learning and teaching (NTECF, 2017).

Teachers’ Contextual Knowledge and Curriculum Implementation

Shulman (1987) initially emphasises the need for contextual knowledge in education to make classroom teachers understand and promote their students’ learning. Building on this, Goldkuhl and Braf (2001) view contextual knowledge as the understanding of how knowledge is situated, created, transferred and utilised in different situations. Grossman (1990) summarises contextual knowledge into the knowledge of students (learners), community, school and district. Carlsen (1999) further categorises contextual knowledge into specific context knowledge and general educational context knowledge. The specific context knowledge includes classroom and student knowledge, while general educational context knowledge constitutes knowledge of the community, school, and nation within which education is organised.

For a 21st-century teacher to appreciate the various dimensions of teaching and learning, contextual knowledge is crucial. As indicated in the National Teacher Education Curriculum Framework (NTECF, 2017), teachers

need contextual knowledge to respond to the increasingly diverse learning classroom environment. Teachers are expected to demonstrate knowledge of the classroom, various cultural and socio-linguistic diversities as well as knowledge of the learner to help facilitate teaching and learning. Again, the NPECF (2018) recommends that a standards-based classroom emphasises teachers' ability to honour learners' diversity, as well as activation of instruction in line with learners' prior knowledge and experiences and background information. Hence, the need for teachers to show knowledge of the classroom, students, school, culture and community contexts of learning.

Teachers' contextual knowledge plays a critical role in teaching and for that matter curriculum implementation. For instance, the NTECF (2017) emphasises that knowledge of context enables teachers to understand learners in terms of their socio-cultural and linguistic background. Similarly, Johnson (2002) opines that contextual teaching and learning make instruction meaningful to learners in the sense that learners can connect instruction to a real-world situation. The author further indicates that it makes it possible for teachers to draw on learners' diverse skills, interests, experiences, and cultures. These are integrated into what and how students learn and are assessed (Johnson, 2002). Crawford (2001) maintains that teaching contextually makes it possible to relate, experience, apply, cooperate and transfer learning. This suggests that teachers' contextual knowledge needs to be given serious attention.

Therefore, building on Shulman's position and other positions (Carlsen, 1999; Grossman, 1990), this study considers teachers' contextual knowledge about the standards-based mathematics curriculum as knowledge of learning

contexts (classroom, school, community and culture) as well as knowledge of the learner (see the conceptual framework, figure 3, p. 34). Hence, the subsequent sections provide a review of these sub-dimensions or variables of teachers' contextual knowledge about the standards-based mathematics curriculum.

Knowledge of Learning Contexts (classroom, school, community and culture)

Knowledge of learning contexts is considered a sub-dimension or variable of teachers' contextual knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Learning contexts are places, environments or situations where learning takes place or where learners construct knowledge. These include classroom environment, school environment, community, learners' culture and so forth. These learning environments serve as a meaningful medium through which effective instruction is organised (Oluwatelure, 2010) and an important facet that affects teaching and learning (Akomolafe & Adesua, 2015). These indications suggest that learning contexts such as the classroom environment, school environment, community and learners' culture need to be given serious attention in the process of teaching and learning.

The classroom is an environment where students and teachers interact around the curriculum (Talbert & McLaughlin, 1999). It is a multifaceted learning context. Turner and Meyer (2000) are of the view that a classroom learning environment is multiple and interconnected contexts of learning where diverse beliefs, values, and perceptions are shared. Students come to the classroom with different backgrounds, information and experiences. In line with

this, Maphalala (2017) argues that educators should be responsive by incorporating the various facets of the learner such as their social and emotional growth. Similarly, instructional practices should be linked to learners' real-life situations and experiences. Educators are to adjust instruction for different learning styles and utilise a variety of teaching and learning methods to create chances for effective learning for every learner (Hattie, 2009; Orlich et al., 2012, cited in Bascia, 2014). This makes content relevant to learners, easier to understand and contributes to their learning progress.

Talbert and McLaughlin (1999) argue that the classroom learning environment exists within the school and wider community. Communities have cultural experiences within which schools are situated. These cultural experiences support teaching and learning. For instance, Ethnomathematics researchers (Ascher, 1991; Bishop, 1988; D'Ambrosio, 1985; Pompeu, 1994; Presmeg, 1996a) point to the cultural nature of mathematics. Also, Bishop (1988) proposes in the cultural curriculum or enculturation curriculum that pedagogical activities, content and assessment of the school curriculum for mathematics should reflect the school community and socio-cultural context of the learner. It suggests that teachers need to be knowledgeable about their students' cultural activities as well as their community practices. According to Vygotsky (1987), learners' rich experiences from their socio-cultural environment provide the impetus to link learners' every concept to school mathematics. It suggests that, when teachers have a total grasp of students' cultural activities, it becomes possible to link everyday mathematics concepts and school mathematics concepts. Naresh (2015) argues that, with the knowledge of students' culture and community practices, teachers transform

and empower students in their learning when they adopt culturally responsive pedagogy, where teaching and learning mathematics is connected to students' socio-cultural contexts.

The standards-based mathematics curriculum recommends teaching and learning in contexts. As emphasised in the learning and teaching philosophy of the standards-based mathematics curriculum, teachers are to contextualise mathematics instruction by linking it to learners' prior experiences, which makes them construct their knowledge and understanding (NaCCA, 2019). Similarly, the National Teacher Education Curriculum Framework (NTECF, 2017) expects teachers to demonstrate contextually oriented understanding in the process of teaching and learning. By doing this, instruction becomes meaningful and relevant to learners which develops them into critical thinkers and problem solvers (NaCCA, 2019). This suggests that teachers' knowledge of learning contexts is crucial.

Knowledge of the Learner

Knowledge of the learner (student) is considered a sub-dimension or variable of teachers' contextual knowledge about the standards-based mathematics curriculum (see the conceptual framework, figure 3, p. 34). Knowledge of learners is diverse and multifaceted, which includes knowledge of students' characteristics, learning styles and needs, abilities, strengths and weaknesses, emotions and beliefs, prior experiences, development, motivation, and so forth. It is considered one of the important pieces of knowledge of teachers necessary for effective teaching and learning (Carlsen, 1999; Grossman, 1990; Morine-Dersheimer & Kent, 1999; Rollnick, Bennett, Rhemtula, & Ndlovu, 2008; Shulman, 1987).

The National Teacher Education Curriculum Framework (NTECF, 2017) emphasises the need for teachers to recognise learners' context in the process of teaching and learning. Therefore, it is expected that teachers demonstrate knowledge of students' characteristics, how students learn and their learning styles as well as knowledge of how to manage students' behaviour (NTECF, 2017). The aim was to make the Ghanaian teacher appreciate and understand the various contexts of the learner and how best instruction could be organised around these contexts for effective teaching and learning. Similarly, the National Pre-tertiary Education Curriculum Framework (NPECF, 2018) recommends teachers maximise instruction to benefit every learner by linking teaching and learning to learners' prior experiences and background knowledge, interests, abilities and individual differences.

Teachers' knowledge of learners is crucial. For instance, Mayer and Marland (1997) indicate that possessing knowledge of students is a vital ingredient for effective teaching and learning as it helps to understand learners' learning styles, present knowledge, learning needs, social and cultural backgrounds, beliefs, values and attitudes as well as learners' motivation for learning. In the view of Dunn, Griggs, Olson, Gorman and Beasley (1995), knowledge of students such as their characteristics and learning styles helps to adjust teaching and learning to suit them which improves their grade points. This suggests that teachers with good knowledge of their students stand the chance of contributing to their students' learning gains.

Empirical Review

The section below further provides an empirical review of the variables discussed in the study pertaining to teachers' knowledge and implementation of

the standards-based mathematics curriculum. Further, an empirical review is provided on teachers' curriculum implementation, the influence of teachers' knowledge on curriculum implementation and students' academic performance, and studies on teachers' knowledge, demographic characteristics and curriculum implementation.

Studies on Teachers' Content Knowledge Variables and Curriculum Implementation

This section provides an empirical review of teachers' knowledge of the organisation and structure of curriculum, expected learning behaviours (learning domains), instructional expectations and core competencies pertaining to curriculum implementation. Regarding knowledge of expected learning behaviours (learning domains), many studies have explored teachers' knowledge, understanding and utilisation of learning domains. For instance, Katam and Jepchirchir (2018) conducted a descriptive study to ascertain how teachers of primary schools understand and apply learning domains during instruction in the classroom, and the extent they address the learning domains. The sample was 353 teachers in primary schools. The findings revealed that the teachers did not fully understand learning domains and were not able to properly employ them in the learning process in the classroom. The findings further revealed that the teachers over-relied on the lower level of knowledge and comprehension, neglecting the higher-order level of cognition.

Bitok (2020) carried out a descriptive study to ascertain teachers' utilisation of the learning domains. The sample was 241 early childhood development education teachers. The findings indicated that even though most of the teachers were not fully acquainted with the learning domains or the

expected learning behaviours, they demonstrated awareness of the learning domains. An indication that the teachers were familiar with the expected learning behaviours.

Similarly, Rupani and Bhutto (2011) conducted a qualitative study to evaluate the existing teaching and learning process on Bloom's taxonomy. The findings revealed that the higher-order levels of knowledge were poorly touched, especially in mathematics and languages with more emphasis on the lower-order levels of knowledge. The findings further indicated that most of the teachers did not even touch the affective and psychomotor learning domains. The findings indicated that even though teachers utilised learning domains in their teaching and learning process, they still did not fully utilise the higher-order learning domains, which may be due to their lack of understanding of how to apply them.

Concerning knowledge of core competencies, many studies have explored teachers' knowledge and integration of core competencies. For instance, Newhouse (2002) and Pelgrum (2001) found that many teachers were unable to integrate ICT-based learning activities because they lacked the necessary competence. Kumari and D'Souza (2016) conducted a descriptive survey to ascertain the digital literacy of teachers and their utilisation of ICT in the process of teaching and learning. The results revealed average teachers' knowledge of digital literacy as well as ICT use. The result further showed a positive significant relationship between teachers' knowledge of digital literacy and ICT use.

On knowledge of teachers regarding problem-solving, critical and creative thinking skills, Asoma, Ali, Adzifome and Appiah-Kubi (2022)

investigated Junior High School Mathematics teachers' knowledge and practices of problem-solving using explanatory sequential design. The findings revealed that teachers' knowledge and practices of problem-solving were moderate. Banks (2014) assessed the knowledge of in-service and pre-service teachers on problem-solving skills. The findings indicated that both groups did not demonstrate acceptable problem-solving skills.

Schulz and Fitzpatrick (2016) investigated Kindergarten teachers through to grade 9 teachers on their knowledge and use of critical and higher-order thinking. The results revealed teachers' inadequate knowledge regarding critical and higher-order thinking skills. Similar findings indicated pre-service teachers' lack of knowledge and utilisation of critical thinking (Bakir, 2015; Sendag, Osman, Sezgin, & Dulkadir, 2015). On teachers' knowledge of creativity, Hana and Hacène (2017) found that teachers lack understanding. The result further indicated that poor knowledge of creative thinking skills inhibited its integration into classroom activities.

Mahama (2022) adopted a descriptive cross-sectional survey to assess the core component of the standards-based curriculum, specifically the creative nurturing behaviours exhibited by the in-service teachers about the standards-based curriculum implementation. The sample was 768 in-service teachers. Data collection was through a questionnaire. Overall, the findings revealed that most of the in-service teachers exhibited a low level of nurturing behaviours in creativity. This indicates the teachers' limited understanding of creativity.

Isaboke (2021) adopted a correlational research design to investigate teachers' preparedness and competency-based curriculum implementation (a similar version of a standards-based curriculum) in pre-primary public schools.

One of the study's objectives was to investigate teachers' ability to integrate core competencies in their process of teaching and learning. The sample was 180 respondents (comprising 90 teachers, 45 school managers and 45 head teachers) randomly selected. Data analysis from a questionnaire, interview schedules, observation schedules and document analysis guide showed that 57 % of teachers trained on CBC demonstrated a good ability to infuse communication and collaboration. Similarly, the result revealed that 50 % of the trained teachers on CBC exhibited a good ability to infuse critical thinking and problem-solving, while 72% of the non-trained teachers on CBC were developing the ability to infuse critical thinking and problem-solving.

Additionally, the findings indicated that 47 % of the trained teachers on CBC demonstrated a good ability to infuse imagination and creativity, while 52 % of the non-trained teachers were developing the ability to infuse imagination and creativity. The result again indicated that 50% of the trained teachers exhibited good ability to infuse citizenship, and 31% of the non-trained teachers were developing the ability to infuse citizenship. The findings further showed that 50% of the trained teachers on CBC needed support to infuse digital literacy, while 74% of the non-trained teachers needed the same support to infuse digital literacy. The findings revealed a significant relationship between teachers' training and competency-based curriculum implementation [$\chi^2(2, 88) = 32.496, p = 0.000$]. This suggested that knowledge and training could be determining factors for effective curriculum implementation.

Studies on Teachers' Pedagogical Knowledge Variables and Curriculum Implementation

This section deals with an empirical review of teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and ICT as a pedagogical tool in relation to curriculum implementation. Regarding teachers' knowledge and utilisation of learner-centred pedagogy, Chiphiko and Shawa (2014) investigated primary teachers' implementation of learner-centred approaches by adopting a qualitative method. The sample was 12 primary school teachers. Data analysis from in-depth interviews, classroom observation and document analysis showed that the teachers were aware of learner-centred approaches and appreciated the need for learner-centred instruction. However, they were unable to utilise them due to a lack of pedagogical knowledge, insufficient materials for teaching and learning, and facilities for learning.

Chibunn, Unamba and Olawuyi (2017) conducted a descriptive survey design to ascertain the awareness of teachers and their utilisation of learner-centred approaches regarding mathematics curriculum implementation. The sample was 100 primary school mathematics teachers. Data analysis from the questionnaire indicated that the mathematics teachers were aware of learner-centred pedagogy. However, in terms of their use, very few teachers utilised them for implementing the mathematics curriculum.

Khadka, Joshi, Adhikari and Khanal (2022) conducted a survey to examine teachers' practice of learner-centred instruction for online mathematics classes and its effects on learning achievement for mathematics. Data analysis from the questionnaire showed that the teachers' online learner-centred

instruction was higher, suggesting the teachers' use of learner-centred instruction for the online mathematics class. Also, the teachers used problem-solving and creativity approaches more indicating their knowledge of them. The findings further indicated that when the learner-centred approach was incorporated with technology, it improved learners' mathematics achievement.

The review suggested that most teachers were aware of learner-centred pedagogy. However, in terms of its use in the classroom situation, most teachers did not integrate it fully into the teaching and learning process. Among other factors accounting for this was the teachers' lack of knowledge.

Concerning teacher knowledge and utilisation of inclusion and equity pedagogy in the classroom, Deku and Vanderpuye (2017) conducted a survey study to assess the perspectives of teachers towards inclusion in Ghana. The sample was 120 teachers. Data analysis from a questionnaire showed that 55% of the teachers admitted they lacked competence in teaching all children in an inclusive classroom environment. This indicates a deficiency of knowledge of inclusive pedagogy in handling children with diverse needs.

Alemayehu (2020) conducted an embedded concurrent mixed methods study to assess primary school in-service teachers' knowledge about inclusion pedagogy. The sample was 146 teachers in primary schools for the quantitative data and 8 teachers for the qualitative data. Data analysis from the questionnaire, interview and document analysis showed the teachers' marginal knowledge of inclusion pedagogy. This indicates the level of inclusion pedagogy utilisation in meeting students' diverse needs and abilities in the classroom.

Kyriazopoulou, Karalis, Magos and Arvanitis (2022) conducted an explanatory sequential mixed methods study to assess preschool teachers'

training needs, knowledge and skills of inclusion education implementation. The sample was 300 preschool teachers for the quantitative data and 15 interviews for the qualitative data. Data analysis from the questionnaire and the interview protocol indicated that the teachers possessed moderate knowledge of implementing inclusion education. Further findings showed the teachers' interest in inclusion, but a lack of knowledge among others challenges its implementation.

Jackson (2013) assessed elementary mathematics teachers' knowledge about equity pedagogy through a qualitative approach. The sample was 8 elementary teachers. Data analysis from a semi-structured interview and field observation indicated that teachers with good equity pedagogy knowledge were proficient in teaching African American students mathematics. It further suggested that such teachers are aware of their students' backgrounds and diverse nature.

Mónico et al. (2020) conducted a cross-cultural investigation to assess the perceptions, knowledge and attitudes of teachers regarding inclusion. Three hundred and sixty-three (363) Ghanaian, German and Spanish teachers form the sample size. MANCOVA analysis indicated teachers' knowledge of instructional strategies and students' characteristics about inclusion pedagogy. It was revealed that the teachers' knowledge of students' characteristics was more than their knowledge of the instructional strategies about inclusion pedagogy. The findings further indicated that Ghanaian teachers had knowledge of students experiencing behaviour and emotional disorders but demonstrated less attitudes towards inclusion.

The findings from the review pointed out that teachers' knowledge of inclusion and equity pedagogy was not high, even though most teachers showed interest in integrating it into their teaching and learning processes.

Pertaining to teachers' knowledge and utilisation of differentiation and scaffolding pedagogy, a number of studies have assessed this in the classroom. For instance, Kyeremeh, Adzifome and Amoah (2022) conducted an explanatory sequential design to assess in-service mathematics teachers' differentiated instruction knowledge. The sample was 50 Junior High School mathematics teachers selected using a proportionate stratified sampling technique. Data analysis from a questionnaire and semi-structured interviews showed that, on average, in-service mathematics teachers in junior high schools possessed high differentiated instruction knowledge.

Mengistie (2020) conducted a mixed-method study to assess knowledge, attitude, and utilisation of differentiated instruction among teachers in primary schools. The sample was 150 teachers selected through a stratified random sampling technique. Data analysis from the questionnaire and focus group discussion indicated that teachers in primary schools possessed sufficient differentiated instruction knowledge. However, its implementation was low.

Ako, Osei, Asare and Amihere (2019) conducted a similar study adopting an explanatory sequential design. The sample was 75 teachers in Junior High Schools selected through a simple random sampling technique. Data analysis from classroom observation and a questionnaire showed that teachers in Junior High Schools demonstrated highly differentiated instruction knowledge. However, in terms of its implementation, the findings showed that the teachers hardly apply differentiated instruction to satisfy learners' diverse

needs. This suggests that many of the teachers usually adopt the traditional approach of “one-size-fits-all” in lesson delivery.

Mahharrini, Ansari and Yani (2020) carried out a qualitative study to examine in-service teachers’ scaffolding when teaching and learning mathematics. The sample was 2 mathematics teachers in a Junior High School. Data analysis from classroom observation revealed that even though the teachers provided some scaffolding strategies, they were unable to utilise them properly. The recommendation indicated that the teachers needed to be equipped with appropriate strategies to ensure effective scaffolding. An indication that the teachers were not properly equipped with knowledge of scaffolding and its implementation.

Li and Zou (2021) conducted a qualitative study to examine English as a Foreign Language (EFL) regarding teachers’ expertise in primary schools about scaffolding. The sample was 30 teachers including both experienced and non-experienced teachers. Data analysis from interviews and classroom observation showed that the expert teachers used scaffolding strategies more than the other group. This could be attributed to the expert teachers’ knowledge and experience. An indication that knowledge and experience could contribute to practices in the classroom.

The review’s findings suggested teachers had considerable knowledge about differentiation and scaffolding pedagogy. However, in terms of utilisation in the classroom situation, most teachers hardly applied them. This may be due to teachers’ limited pedagogical skills.

Concerning teachers’ knowledge about ICT and its integration during teaching and learning, various studies have investigated this. For instance,

Mukenya, Wanjala and Shikuku (2020) conducted a descriptive survey design to examine the knowledge and skills of mathematics teachers in secondary schools about ICT integration into classroom instruction. The sample was 218 teachers selected through a proportionate stratified sampling technique. Data analysis from a questionnaire, interview and observation schedules showed that the mathematics teachers exhibited insufficient skills and knowledge regarding ICT utilisation.

Ndibalema (2014) adopted a mixed-method approach to assess the attitude of teachers in secondary schools concerning ICT usage. One objective was teachers' usage and knowledge of ICT. The sample was 80 secondary school teachers selected randomly. Data analysis from a questionnaire and interviews showed that the teachers had low familiarity with ICT and were ineffectively utilised in teaching and learning, even though they showed good attitudes toward using ICT.

Mailizar and Fan (2020) adopted a quantitative approach to assess mathematics teachers in upper secondary knowledge about ICT and its usage in teaching mathematics. The sample was 341 mathematics teachers. Data analysis from the questionnaire revealed that the mathematics teachers possessed inadequate knowledge of ICT. Regarding its usage in the process of teaching and learning, the results indicated the teachers' lack of knowledge to utilise ICT as a pedagogical tool.

Obielodan, Omojola, Tijani and Samuel (2020) adopted a descriptive cross-sectional survey design to examine the pedagogical knowledge of teachers in secondary schools about ICT utilisation. The sample was 333 teachers selected proportionately. The results from the questionnaire pointed out

that the teachers had low pedagogical knowledge of utilising ICT tools for teaching. The findings also showed that the teachers did not even utilise the available ICT tools frequently. An indication that suggests little implementation of ICT as a pedagogical tool.

Buabeng-Andoh (2019) adopted a quantitative approach to assess what influences secondary school teachers' use of ICT. The sample was 376 respondents selected randomly. The study's findings from the questionnaire showed that the teachers had high perceived value and expectations of the success of ICT integration. However, this did not correlate strongly with their ICT usage. This suggests that even though the teachers value the importance of ICT and expect great success in ICT implementation, they hardly apply ICT in their teaching. Again, the findings indicated that the teachers lacked the necessary skills for ICT integration in the process of teaching.

Alam and Khurshid (2020) adopted a descriptive survey design to investigate the knowledge and pedagogical beliefs of teachers in elementary schools concerning ICT integration in the process of teaching and learning. The sample was 100 teachers selected randomly. Data analysis from the questionnaire revealed that the teachers' knowledge of ICT is a strong predictor of their use of ICT in the classroom. This suggests that knowledge of ICT could determine its usage in the classroom.

Singh and Chan (2014) adopted a quantitative approach to investigate in-service teachers' knowledge, attitudes and ICT usage in the process of teaching and learning. The sample was 50 secondary school in-service teachers. Data analysis from the questionnaire indicated moderate knowledge of teachers about ICT. In terms of its use, the findings revealed that the majority of the

teachers often used ICT for teaching, and also demonstrated a positive attitude towards it.

Kamaruddin, Abdullah, Idris and Nawi (2017) conducted a survey design to assess preschool teachers' knowledge and skills, integration and problems faced in using ICT. The sample was 61 preschool teachers. Results from the questionnaire revealed that the majority of the teachers were knowledgeable about ICT as a tool for teaching. However, its usage in the process of learning and teaching was low. The findings suggested that teachers did not demonstrate enough competence for ICT integration in the process of teaching and learning which may be due to their limited ICT knowledge and its utilisation.

Studies on Teachers' Pedagogical Content Knowledge Variables and Curriculum Implementation

This section provides an empirical review of teachers' knowledge of learners' learning and assessment practices in relation to curriculum implementation. Pertaining to teachers' knowledge of students' learning in the classroom situation, a number of studies have explored this. For instance, Essa and El-Zeftawy (2015) adopted a cross-sectional design to assess teachers' knowledge, attitudes and strategies of students with learning difficulties. The sample was 476 teachers selected conveniently. The findings showed that the teachers had a fair knowledge of students' learning difficulties. The findings also showed that the difference in teachers' knowledge of students' learning difficulties for rural and urban teachers was significant ($p < 0.05$).

Kılıç (2011) adopted a qualitative study to assess pre-service mathematics teachers' understanding of students in secondary schools. The

sample was 6 teachers. The results showed that the teachers had limited knowledge of students in terms of their understanding of students' common difficulties and errors. The findings further revealed that the teachers were unable to analyse the reasons for students' difficulties and errors.

Morrison and Lederman (2003) adopted an observational study to assess how science teachers diagnose and understand students' preconceptions. A total of 4 teachers were intensively observed in a classroom situation coupled with pre-observation and post-observation interviews. The results revealed the teachers' weak understanding of students' preconceptions. Similarly, the findings revealed that the teachers had difficulties in diagnosing such preconceptions.

Çelik and Güzel (2017) conducted a qualitative study to examine the knowledge of students' thinking and confirmation of practice in the classroom of mathematics teachers. A total of 3 mathematics teachers were intensively observed. Data analysis from the observation in the classroom and teachers' interviews showed that the teachers were unable to prompt pupils to notice the causes of their errors and misconceptions. That is, the teachers were unable to notice the possible misconceptions of their students. An indication of teachers' limited knowledge of students' learning. The review appears to indicate teachers' limited knowledge of students' learning when it comes to identifying students' learning difficulties, preconceptions and misconceptions in the process of teaching and learning.

Regarding the knowledge of teachers about practices of assessment, many studies have investigated this. For instance, Akayuure (2021) adopted a descriptive research design to assess teachers of mathematics in senior high

schools' literacy levels of classroom assessment regarding how to choose methods of assessment appropriately, develop assessment tasks properly, administer, score and interpret results correctly, take assessment decision rightly, develop valid procedures for grading, communicate results of assessment, and acknowledge the use of assessment information in an unethical manner. The sample was 96 teachers selected through purposive sampling. The results from the questionnaire showed that most of the teachers did not meet the literacy assessment requirement standards. This indicated that many of the teachers demonstrated insufficient knowledge of classroom assessment practices.

Akyina and Oduro-Okyireh (2019) adopted a descriptive research design to assess the formative assessment practices of teachers in senior high schools. One objective was to assess the teachers' knowledge of formative assessment practices. The sample was 80 teachers selected through stratified and simple random techniques. Data analysis from the questionnaire indicated that approximately half of the teachers had no idea about formative assessment practices. This indicated the teachers' limited knowledge of assessment practices.

Amoako, Asamoah and Bortey (2019) adopted a descriptive survey design to assess teachers of mathematics knowledge and practice of formative assessment in senior high schools. The sample was 148 mathematics teachers selected through a census approach. Data analysis from the questionnaire showed that the teachers had low knowledge of formative assessment practices. The findings further revealed a positive strong correlation between teachers' knowledge of assessment and practice in the classroom situation [$r(148) = .821$,

$p < .001$ (2-tailed)]. This indicated that the teachers' knowledge of assessment influenced their assessment practices in the classroom. That is, high assessment knowledge corresponds with high assessment practices, and low assessment knowledge corresponds with low assessment practices.

Yamtim and Wongwanich (2014) investigated primary school teachers to assess their assessment literacy. Assessment literacy constitutes the necessary skills and knowledge for assessment practices. The sample was 19 primary school teachers. Data collection was through a questionnaire and a focus group discussion. The results showed that most of the teachers demonstrated low assessment literacy. An indication of the teachers' insufficient knowledge of assessment practices.

Matsenjwa and Thwala (2013) adopted a survey design to assess primary school teachers' skills and knowledge of measurement and assessment. The sample was 72 primary school teachers selected randomly. Data analysis from the questionnaire revealed that the teachers had some knowledge of measurement and assessment. However, the findings indicated that the teachers lacked the skills to use multiple techniques of assessment. This suggested that even though the teachers demonstrated knowledge of assessment, they lacked the skills to use a variety of assessment techniques in their teaching and learning process. The review seems to suggest that the knowledge of teachers regarding assessment practices was not up to an appreciable level. Most of the studies pointed to teachers' limited knowledge of assessment practices in the process of teaching and learning.

Studies on Teachers' Contextual Knowledge Variables and Curriculum Implementation

This section deals with an empirical review of teachers' knowledge of learning contexts (classroom, school, community and culture) and knowledge of the learner with regard to curriculum implementation. Concerning the knowledge of teachers about learning contexts, some studies have explored this. For instance, Amesi, Akpomi and Amadi (2014) adopted a descriptive survey design to assess teachers' knowledge and application of classroom management techniques. The sample was 86 teachers selected through purposive sampling. One task was to assess the extent of teachers' knowledge of classroom management techniques. The variables include teachers' knowledge of students' backgrounds, the socio-economic background of students' families, and knowledge of students' individual differences and needs. Data analysis from the questionnaire indicated that the teachers were yet to be knowledgeable on matters like students' background, the socio-economic background of students' families, and students' individual differences and needs. This indicated that the teachers demonstrated insufficient knowledge of learning context issues.

Siddiqui and Ahamed (2020) adopted a concurrent mixed-method design to explore teachers' roles beyond and within context. The sample was 30 teachers. One objective was to assess how teachers cope with variables such as learning environment and learning styles. Data analysis from the questionnaire, interview and focus group discussion indicated that the teachers paid less attention to learners' social and cultural backgrounds as well as their learning

styles. The review appears to suggest that teachers did not demonstrate much understanding of various contexts of learning.

In relation to the knowledge of teachers about their students, Mayer and Marland (1997) investigated 5 primary teachers to assess their knowledge of the students they teach, how they acquire such knowledge and the ways it is used in the process of teaching and learning. The results showed that the teachers possessed extensive knowledge about the class they teach, groups within their class and at least some individual students. The findings pointed out that such knowledge formed an integral part of teachers for effective teaching.

Studies on Teachers' Mathematics Curriculum Implementation

Studies have explored teachers' implementation of a curriculum in the classroom situation with different outcomes. Ampadu (2013) adopted a mixed-method approach to assess the beliefs and practices of teachers of mathematics for implementing a new curriculum for mathematics. The sample was 41 Junior high school mathematics teachers selected randomly. One target was to assess the mathematics teachers' teaching beliefs, the curriculum requirements, and the way they teach. Data analysis from a semi-structured questionnaire and classroom observation revealed that the teachers' perceived teaching beliefs conform to the requirements of the mathematics curriculum. However, the teachers' perceived teaching beliefs were not fully consistent with their actual classroom practices. That is, even though the teachers had knowledge about the teaching requirements of the mathematics curriculum, what they implemented in the classroom was not fully in line with the prescriptions of the mathematics curriculum.

Rudhumbu and Rudhumbu (2018) adopted a descriptive survey design to assess teachers of primary schools' implementation of the school curriculum for mathematics. The sample was 620 primary teachers selected through a stratified random sampling technique. One objective was to assess the teachers' strategies for implementing the primary school mathematics curriculum. Data analysis from a questionnaire revealed a low quality of implementation of the mathematics curriculum with most of the teachers relying on teacher-centred pedagogies instead of learner-centred pedagogies. The results also revealed that the teachers hardly integrated technology in implementing the mathematics curriculum.

Mereku (1995) adopted a survey approach to investigate the recommended primary curriculum for mathematics and the way teachers were implementing it. The sample was 138 teachers. One aim was to assess teachers' adaptation to the methods of teaching the prescribed primary curriculum for mathematics in the classroom situation. Data analysis from a questionnaire, classroom observation and document reviews indicated that the teachers mostly utilised the methods of teaching the primary curriculum for mathematics which included expository teaching methods.

Rusdiana and Nasihudin (2018) adopted a qualitative study to assess the national standard-based curriculum implementation. Data analysis from an interview, observation and documentation from project heads, lecturers, students and parents revealed that the implementation of the curriculum was not yet effective. The findings indicated that knowledge support was one factor affecting the way the national standard-based curriculum was implemented.

Kabombwe and Mulenga (2019) adopted a mixed-method approach specifically, an explanatory sequential design to assess teachers' competency-based curriculum implementation (a similar version of a standards-based curriculum). The sample was 80 teachers selected randomly to participate in the study. Data analysis from a questionnaire, interview, observation of classroom lessons and analysis of documents revealed that the teachers were not effectively utilising the teaching approaches of the competency-based curriculum. The findings pointed to teachers' insufficient knowledge and skills of competency-based curriculum as one factor accounting for this.

Garcia and Rosa (2021) adopted a descriptive-evaluative research design to examine teachers' implementation of the school curriculum for mathematics in Junior high schools. One task was examining teachers' mathematics curriculum implementation in terms of content standards, contexts, skills and processes, values and attitudes, as well as the way teachers utilised the curriculum's teaching and learning strategies and methodologies. The sample was 26 mathematics teachers selected randomly to participate in the study. Other respondents included students and administrators. Data analysis from a questionnaire revealed that teachers' mathematics curriculum implementation regarding content standards, contexts, skills and processes, values and attitudes was high. The findings also pointed to teachers' utilisation of the suggested learning and teaching strategies, such as cooperative learning, experiential and situated learning, discovery and inquiry-based learning, and other constructivist teaching approaches, being high.

Pagana, Nyikahadzoyi, Mutambara and Chagwiza (2015) adopted a case study approach to assess the planned and enacted ordinary-level mathematics

curriculum gaps. The sample was 36 ordinary-level (O-level) mathematics teachers selected through purposive sampling. The study's objectives included teachers' interpretations of the mathematics curriculum, how the mathematics curriculum was put into practice and teachers' assessment practices in the classroom discourse. Data analysis from a classroom observation, focus group discussion and analysis of documents revealed that in terms of interpretation, most teachers showed awareness of the aims and objectives for teaching the ordinary-level mathematics curriculum even though they copied them without any interpretation. Also, the findings revealed that the teachers' practices in the classroom contradicted the aims and objectives of teaching the mathematics curriculum. Again, the results pointed to teachers' assessment practices being inconsistent with the recommended authentic assessment practices of the curriculum.

Buddo (2015) adopted a quantitative approach, specifically a survey to assess teachers' implementation reflections on the revised curriculum for mathematics in primary schools. The sample was 37 primary teachers. One aim was to assess how the teachers planned and prepared lessons, the methods they employed for teaching, how they managed and controlled the environment for classroom learning and practices for assessment. Data analysis from a questionnaire revealed that the teachers' reflections on their classroom practices concerning the primary mathematics curriculum implementation were high. The findings further indicated that the teachers mostly adopted traditional assessment practices with limited use of authentic means of assessing students.

Madani and Forawi (2019) adopted a mixed-method approach specifically, a parallel mixed-method design to assess the new curriculum for

mathematics and science. The sample was 547 teachers teaching mathematics and science. One objective was to assess the teachers' recognition of the new curriculum's major aspects and the way teachers implemented the new mathematics and science curriculum. Analysis of data from a questionnaire, interview and observation in the classroom showed the teachers were aware of and applied the new instructional practices, such as student-centred pedagogies, project-based activities, hands-on activities, and relating concepts to students' daily life issues about the new curriculum for mathematics and science. Again, the findings pointed out that the teachers were well prepared, but their preparedness differed across the teachers.

The review appears to suggest that teachers implemented school mathematics curricula differently. For instance, in some cases, teachers' classroom implementation practices were in line with the prescribed practices of the intended curriculum, while in most cases, teachers' implementation practices showed no conformity with the practices of the intended curriculum. Some factors contributing to this were the teachers' limited knowledge of the prescribed curriculum, interpretation and application of recommended pedagogical approaches.

Studies on Influence of Teachers' Knowledge on Curriculum Implementation

Various studies have been carried out to examine the influence of teachers' knowledge on curriculum implementation with different outcomes. For instance, Chemagosi (2020) conducted a descriptive survey design to investigate the preparedness of teachers for a new competency-based

curriculum implementation (similar to the standards-based curriculum) in public schools at the lower primary.

The sample was 48 teachers. One task was to assess the teachers' competence regarding knowledge of the subject content matter. Data collection was conducted through a questionnaire and interview guide. A simple linear regression analysis revealed that the teachers' preparedness significantly influenced the new competency-based curriculum implementation [$\beta=.34$, $t(47) = 7.99$, $p < .05$]. This indicated that the teachers' preparedness in terms of their competency-based curriculum knowledge contributed to how they implemented the curriculum.

Rwigema and Andala (2022) adopted a mixed-method approach to assess the influence of factors relating to teachers such as pedagogical and content knowledge, skills of technology and perceptions about competency-based curriculum implementation (similar to the standards-based curriculum). The stratified method of sampling was employed to choose a sample of 132 teachers in primary schools. Data were gathered qualitatively and quantitatively in a concurrent manner through an interview guide and a questionnaire respectively. The findings from the multiple regression analysis revealed that the teachers' content and pedagogical knowledge [$\beta=.44$, $t(105) = 1.82$, $p < .05$] significantly influenced the competency-based curriculum implementation. Similarly, the teachers' technological skills [$\beta=.1.23$, $t(105) = 3.62$, $p < .05$] significantly influenced the curriculum implementation. The results showed that teachers' content and pedagogical knowledge as well as technological skills could affect the way they implemented the school curriculum.

Sidow (2022) adopted a quantitative approach to assess the influence of factors such as teachers' professional development, supervision and materials for instruction on competency-based curriculum implementation in secondary schools at the public level. Teachers' professional development constitutes teachers' skills, knowledge and expertise for effective teaching. The sample was 292 teachers selected randomly. Data collection was gathered through a questionnaire. The findings from the multiple regression analysis revealed that the professional development of teachers in terms of their knowledge, skills and expertise for effective teaching ($\beta=.77$, $t =20.73$, $p < .001$) significantly influenced the competency-based curriculum implementation.

Kisulu, Simatwa and Ndolo (2021) adopted a mixed-method approach to assess the influence of public primary teachers' technical skills such as pedagogical skills, content coverage and pre-service training competence on competency-based curriculum implementation. Data collection was through a questionnaire and an interview guide. A multiple regression analysis of data from 80 grade 3 teachers revealed that the teachers' technical skills in terms of their pedagogical skills, content coverage and pre-service training significantly influenced the competency-based curriculum implementation [$\beta=.38$, $t (78) = 2.55$, $p < .05$]. This suggested that teachers' pedagogical skills, content coverage and pre-service training could affect how they implement a curriculum.

Ghanney and Agyei (2021) adopted a mixed-method approach, specifically a concurrent design to assess the pedagogical content knowledge (PCK) and assessment practices of teachers in Junior high schools. A census approach was used to select a total of 77 teachers. Among the components of the PCK was to assess the teachers' awareness and ability to address students'

possible learning difficulties, and understanding. Data collection was gathered through a questionnaire, a document analysis guide, and an observation checklist. Data analysis revealed that the teachers' PCK had a positive strong relationship with their assessment practices [$r(77) = .819, P < .001$ (2-tailed)]. This indicated that the teachers' knowledge of PCK corresponded with their assessment practices. It further suggested that teachers' knowledge of PCK could influence their assessment practices in the classroom.

Kosgei (2015) conducted an ex-post facto design to assess the influence of factors relating to a school on an alternative "B" mathematics curriculum implementation. The sample was 578 respondents (comprising 401 teachers of mathematics, 20 mathematics heads, and 157 principals) selected randomly for the study. Data collection was gathered through a questionnaire and interview schedules. The results revealed that school-based factors such as the knowledge of the classroom influenced the alternative 'B' mathematics curriculum implementation.

Gani and Mahjaty (2017) conducted a quantitative study to investigate teachers' knowledge of the new 2013 curriculum which is similar to the standards-based curriculum. One task was to assess the teachers' knowledge of the new curriculum regarding content, standards of process and standards of evaluation. The findings revealed that the teachers demonstrated low knowledge of standards of content with an average score of 40%, poor knowledge of standards of evaluation with an average score of 36%, and intermediate knowledge of standards of the process with an average score of 41%. The findings further pointed out that the teachers' overall knowledge of the new 2013 curriculum was poor affecting its implementation.

Carreon (2020) conducted a descriptive study to examine the content knowledge of teachers concerning the K-12 curriculum highlights. The sample was 31 teachers from different learning sectors and grade levels. One aim was to assess the knowledge of teachers regarding the K-12 curriculum's overall goals, content standards, performance standards and learning competencies, and knowledge of key components of the curriculum. The overall post-assessment result analysis showed high content knowledge of teachers and understanding of the K-12 curriculum's underlying principles and its implementation.

The review appears to suggest that teachers' knowledge influenced how they implemented a school curriculum. High knowledge of teachers seemed to correspond with high curriculum practices, and low knowledge of teachers seemed to correspond with low curriculum practices.

Studies on Influence of Teachers' Knowledge on Students' Academic Performance

Various studies have examined the influence of teachers' knowledge on the academic performance of students. For instance, Damien and Claire (2022) adopted a correlational research design to assess the influence of teachers' preparedness on the academic performance of students. Teacher preparedness constituted knowledge of the classroom environment, effective engagement, expertise in teaching, mastery of the subject taught, effective use of instructional resources, technological skills and readiness in teaching. The sample was 158 public secondary school teachers. Data collection was through a questionnaire, an interview and analysis of documents. The findings revealed a strong positive correlation between the teachers' preparedness in terms of their knowledge and students' academic performance [$r(145) = .817, p < .001$ (2-tailed)]. Further

regressional analysis revealed that the teachers' preparedness in terms of their knowledge influenced students' academic performance. The overall model explained 26.2% of the variance.

Michael, Morre and Casocot (2022) adopted a quantitative approach, specifically a correlational design to assess the influence of pedagogical knowledge and mathematical skills of teachers of mathematics on the performance of students. A stratified technique of sampling was employed to sample the respondents. The teachers' pedagogical knowledge constituted knowledge of cooperative learning, communication skills, technology-based instruction, and problem-based learning. Data collection was done through a questionnaire and observation. The results from the regression analysis indicated no significant relationship between the teachers' pedagogical knowledge and students' achievement ($p > .05$), even though the teachers' pedagogical knowledge was high. It suggested that the teachers' pedagogical knowledge was not a predictor of the students' achievement.

Ali, Busch, Qaisrani and Rehman (2020) adopted a cross-sectional survey design to examine the influence of teachers' professional competencies on students' achievement. The teachers' professional competencies constituted technological, pedagogical and content knowledge. The sample was 385 secondary teachers selected through purposive sampling. Data collection was through a questionnaire. The findings revealed that the teachers' pedagogical ($p < .001$), content ($p = .03$) and technological knowledge significantly influenced the students' achievement. That is, the teachers' pedagogical, content and technological knowledge were significant predictors of the students' achievement.

Olasehinde-Williams, Yahaya and Owolabi (2018) adopted a descriptive survey design to assess how teachers' content and pedagogical knowledge influence students' academic achievement. The sample was 78 mathematics and English teachers selected through purposive sampling. However, seventy-five (75) of these respondents participated in the study. Data collection was through tests and classroom observation. The findings from the regression analysis revealed that both teachers' content and pedagogical knowledge jointly influenced the students' academic achievement significantly [$F(2, 71) = 4.24, p = .01$]. Both accounted for 10.7% of the variance in students' academic achievement. However, individual predictors' unique contributions revealed that the teachers' pedagogical knowledge was not a significant predictor of the students' academic performance [$\beta = -.186, t(71) = -1.633, p = .10$].

Kporyi and Arko (2021) adopted a descriptive survey design to assess the influence of Junior high school teachers' pedagogical competence on students' academic achievement. Teachers' pedagogical competence constitutes the ability to communicate learning goals and procedures, questioning skills, teaching methods, thinking critically and solving problems, use of discussions and working in groups, assessment practices, students' characteristics knowledge, and students' learning and classroom adjustment knowledge. The sample was 250 teachers selected randomly. Data collection was done through a questionnaire. The results from the correlational analysis showed that the teachers' pedagogical knowledge did not correlate significantly with the students' academic achievement [$r(250) = .04, p = .69, (2\text{-tailed})$].

This showed that teachers' pedagogical knowledge did not influence the academic achievement of students.

Yasin (2021) adopted a cross-sectional survey design to assess the effects of the pedagogical processes of teachers on the academic performance of students. The teachers' pedagogical processes constitute knowledge of teaching methods and classroom assessment practices. The sample was 160 primary school teachers selected randomly. Data collection was through a questionnaire. The findings from the One-way ANOVA analysis revealed that the teachers' pedagogical processes had a significant effect on students' academic performance [$F(2, 157) = 43.062, p < .001$]. This indicated that the teachers' pedagogical processes influenced the students' academic performance.

Hakim (2015) adopted a survey approach to examine the influence of teachers' competence on learning performance. One aim was to assess the teachers' pedagogical competence and learning performance. The sample was 117 teachers. Data collection was executed through a questionnaire. The findings from the multiple linear regression analysis revealed that the teachers' pedagogical competence significantly influenced the learning performance ($\beta = 1.24, t = 8.72, p < .001$). This indicated that the teachers' pedagogical competence was a significant predictor of learning success.

Nyanjom, Yambo and Ongunya (2021) adopted a survey design to examine the influence of teachers' knowledge competency on the academic performance of students. Teachers' knowledge competency constituted knowledge of teaching skills, assessment practices and content knowledge. The sample was 294 primary teachers. Data collection was done through a

questionnaire. The results from the correlational analysis indicated that the teachers' content knowledge did not correlate significantly with students' academic performance [$r(294) = .07, p = .21, (2\text{-tailed})$], even though the teachers were well equipped with content knowledge. This showed that the teachers' knowledge competency regarding their knowledge of the content did not influence students' academic achievement.

König et al. (2021) assessed the linkage among teachers' competence in pedagogy, quality of instruction and mathematics achievement of students. The sample was 59 teachers of mathematics from lower secondary schools. One aim was to assess the influence of teachers' knowledge of pedagogy and management of the classroom on students' achievement. The teachers' knowledge of pedagogy and management of the classroom covered their lesson planning and structuring, classroom management and motivation, classroom adaptivity, differentiation strategies, teaching methods and assessment practices. Data collection was through the teachers' pedagogical competence test and students' test based on grade 7 and grade 8 mathematics standards. The findings from the multilevel regression analysis revealed that the teachers' pedagogical competence significantly predicted the students' mathematics achievement.

Kiamba, Mutua and Mulwa (2017) adopted a descriptive research design to examine the influence of teachers' knowledge of subject matter on the academic achievement of students. The sample was 60 teachers. One goal was to assess the teachers' capacity to utilise their knowledge of the subject matter to alternate teaching methods effectively, vary and clarify misconceptions, plan lessons and engage in assessment practices. Data collection was done through a

questionnaire. The results showed that the teachers' knowledge of the subject matter had a positive strong correlation with students' academic performance [$r(60) = .62, p < .001, (2\text{-tailed})$]. This suggested that teachers' knowledge of the subject matter influenced students' performance.

Teygong, Kapkiai and Oduor (2017) adopted a descriptive survey design to assess the influence of the pedagogical competence of teachers on the academic performance of students. The teachers' pedagogical competence constituted their problem-solving techniques, group discussions, and project-based activities. The sample was 226 primary school teachers. However, 184 teachers took part in the study. The collection of data was done through a questionnaire, analysis of documents and interviews. The results from the correlational analysis showed that teachers' pedagogical competence had a weak positive correlation with the students' academic performance [$r(184) = .23, p = .002, (2\text{-tailed})$]. This suggested that the teachers' knowledge of pedagogy did not have a strong influence on the academic performance of the students.

Adeniyi, Ogundele and Odetola (2014) opted for a descriptive survey design to assess the effects of teachers' quality on students' mathematics achievement. The teacher's quality constitutes their pedagogical techniques and classroom control. The sample was 873 teachers and students. Data collection was carried out through a questionnaire and students' previous mathematics achievement scores. The findings from the regression analysis revealed that the teachers' knowledge of pedagogical techniques ($\beta = .128, t = 3.467, p < .001$), and classroom control ($\beta = .089, t = -2.346, p = .01$) significantly influenced students' mathematics achievement.

Nyanjom, Yambo and Ongunya (2020) utilised a survey design to assess the “influence of teachers’ assessment competency on pupils’ academic achievement in Kisumu County”. The sample was 294 teachers. Data collection was through a questionnaire, classroom observation checklists and interview schedules. The findings from the regression analysis and Pearson correlation showed that teachers’ skills of teaching ($p = .02$) and competencies in assessment ($p = .03$) significantly influenced the achievement of the pupils.

The aforementioned review pointed to different outcomes concerning the influence of the knowledge of teachers on the academic performance of students. For instance, in some cases, teachers’ knowledge influenced students’ academic performance, while in other cases, teachers’ knowledge did not influence students’ performance. It suggested that in such cases other factors could also account for students’ performance.

Studies on Teachers’ Knowledge, Demographic Characteristics and Curriculum Implementation

Various studies have explored teachers’ knowledge, demographic characteristics and curriculum implementation. For instance, Al-Awidi and Aldhafeeri (2017) adopted a mixed-method approach to assess teachers’ readiness for a digital curriculum implementation. The teachers’ readiness constituted their pedagogical and technical knowledge and skills about the curriculum. One hypothesis was to test whether the teachers’ readiness (pedagogical and technical knowledge) to implement the curriculum differs across the level of grade they teach (elementary, intermediate, and secondary) and years of experience in teaching. The sample was 591 teachers. The findings from the factorial MANOVA revealed that the pedagogical readiness of the

teachers to implement the curriculum did not differ across their grade levels ($F=2.712$, $p = .06$). However, the pedagogical readiness of the teachers to implement the curriculum differed across their years of experience in teaching ($F= 6.049$, $p < .001$). This indicated that the teachers' pedagogical knowledge to implement the curriculum was not different across the level of the grade they taught, but different across their years of experience in teaching.

Anderson (2020) adopted a sequential mixed-method approach to assess the new national teacher education curriculum implementation. One aim was to test the effects of the implementers' demographic characteristics such as gender and age on the implementers' preparedness to implement the curriculum. The sample was 32 implementers and 250 students. Data collection was done through a questionnaire and an interview. The findings from the multiple regression analysis revealed that the implementers' gender had a significant effect on their preparedness to implement the curriculum ($\beta = -.889$, $t = -5.260$, $p < .001$). Similarly, their age also had a significant effect on their preparedness to implement the curriculum ($\beta = .696$, $t = 3.285$, $p = .003$). This indicated that demographic variables such as gender and age could influence the implementation of a curriculum.

Madani and Forawi (2019) adopted a mixed-method approach, specifically a parallel mixed-method design to assess the awareness of teachers regarding the new mathematics and science curriculum's major aspects and their preparedness. The hypotheses included whether the teachers' awareness and knowledge about the new mathematics and science curriculum differed across their gender and experience in teaching. Also, whether the teachers' awareness of implementing the new curriculum differed across their academic

qualifications. The findings from the T-test result revealed that the teachers' awareness and knowledge about the curriculum did not differ across their gender ($t = 85.148, p = .69$). However, regarding years of experience in teaching, their awareness and knowledge about the new curriculum differed significantly. In addition, the ANOVA test revealed that the teachers' awareness of implementing the new curriculum differed significantly across their academic qualifications [$F(3, 539) = 2.719, p = .03$]. This indicated that teachers' years of experience in teaching and academic qualifications could influence their understanding and implementation of a curriculum.

Amuah, Osei, Dadey and Tsotovor (2022) adopted a descriptive survey design to assess the pedagogical content knowledge (PCK) of teachers for Religious and Moral Education curriculum implementation in Junior high schools. One aim was to test whether the teachers' years of experience in teaching and gender had any effects on their pedagogical content knowledge for implementing the curriculum. The sample was 130 teachers. The findings from the ANOVA result revealed that the teachers' years of experience in teaching had no effects on their pedagogical content knowledge for implementing the curriculum [$F(2, 116) = 1.024, p = .38$]. Similarly, the T-test result revealed that the teachers' gender had no effect.

Nyagah and Gathumbi (2017) adopted a cross-sectional survey design to assess the influence of teachers' characteristics on non-formal basic education curriculum implementation. One task was to test whether the teachers' characteristics such as gender, age, length of service and educational level influenced learners' completion rate which was considered an indicator of successful curriculum implementation. The sample was 96 teachers. Data

collection was carried out through a questionnaire. The findings from the regression result revealed that the teachers' gender ($p = .01$), age ($p = .03$), and educational level ($p = .02$) significantly influenced successful curriculum implementation. However, teachers' length of service ($p = .21$) had no effect on the curriculum implementation.

Owusu and Yiboe (2013) employed a descriptive survey design to assess how teachers' teaching experience, qualifications and perceptions influence their French curriculum implementation. Twenty-one (21) teachers were selected through a census approach. The findings of the study revealed that teachers' teaching experience ($\beta = 0.259$; $t = 0.640$; $p = .53$) and perceptions ($\beta = -0.593$; $t = -1.637$; $p = .12$) were not significant predictors of teachers' curriculum implementation. Only teachers' qualification was found to influence teachers' implementation statistically ($\beta = 0.857$; $t = -2.172$; $p = .04$).

Dunton and Co (2019) utilised a survey correlation design to explore science teachers' implementation of the "spiral progression approach of teaching science". One hypothesis was to test whether a significant relationship existed between teachers' implementation and grade levels. The results showed no significant relationship between teachers' implementation and the grade levels. The review pointed to different outcomes. In some cases, teachers' demographic characteristics influenced their knowledge and curriculum implementation, while in other cases, teachers' demographic characteristics did not.

Chapter Summary

The review of the literature was grounded on the theoretical and conceptual frameworks of the study. Shulman's (1986, 1987) theory of teacher

knowledge and Rogan and Grayson's (2003) curriculum implementation theory underpinned this study, centrally focusing on teachers' knowledge and capacity for curriculum implementation. Using these theories, the conceptual framework of the study was developed which constituted teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum.

Also, the conceptual review included the post-independence development of the mathematics curriculum in Ghana, the standards-based curriculum, its philosophy, and teachers' knowledge and curriculum implementation. The empirical review focused on teachers' content, pedagogical, pedagogical content and contextual knowledge variables and curriculum implementation. Studies on teachers' mathematics curriculum implementation, the influence of teachers' knowledge on curriculum implementation and students' performance as well as teachers' knowledge, demographic characteristics and curriculum implementation were empirically reviewed.

CHAPTER THREE

RESEARCH METHODS

Overview

The study examines the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. Therefore, the Chapter deals with how the study was conducted in order to examine how teachers' knowledge influences their implementation of the curriculum and students' performance. To achieve this, the Chapter was organised into subheadings. These include the research paradigm, research design, study area description, population, sample and sampling procedures, data collection instruments, validity and reliability of research instruments, data collection procedures, ethical considerations, data processing and analysis, and chapter summary.

Research Paradigm

This study was grounded on the pragmatist paradigm. According to Rehman and Alharthi (2016), a research paradigm explains a researcher's worldview in terms of beliefs and assumptions that direct his or her thinking about how to conduct the study. This suggests that, in conducting research, one needs to orient himself/herself towards a particular worldview that serves as a guiding philosophy. A pragmatist argues for "non-singular reality" and supports mixing various strategies to effectively address a problem (Okesina, 2020).

The study was informed by the pragmatist worldview because, in addressing the research questions and hypotheses formulated, it was necessary not to dwell solely on quantitative (positivist) or qualitative (interpretivist or constructivist) means of collecting and analysing data but a mixture of both. For

instance, in addressing research questions 1, 2, 3, 4 and 5, which border on the quantitative aspects of the study, a questionnaire and test were employed for data collection. Similarly, in expanding and explaining certain unique quantitative results obtained on teachers' low, moderate and high knowledge about the standards-based curriculum for mathematics, teachers' low, moderate and high implementation of the curriculum, statistical differences in teachers' curriculum implementation across the grade levels they teach, and statistical differences in teachers' knowledge about the standards-based curriculum for mathematics across their academic qualifications, grade levels they teach, and mode of acquiring their certificates, an interview guide was employed for collecting qualitative data. These are in line with the tenets of pragmatists' perspectives who believe in employing multiple methods in understanding and addressing research problems (Creswell, 2014; Mertens, 2010; Morgan, 2014; Parvaiz, Mufti & Wahab, 2016), and also in compensating for the weakness of one approach of collecting and analysing data as well as enriching data triangulation.

Creswell and Clark (2011) see pragmatism as a research paradigm that offers multiple realities of empirical inquiry. To the pragmatists, one system of philosophy and reality may not be sufficient to study a phenomenon. Goldkuhl (2012) emphasises that using different techniques or a combination of techniques that work to serve the purpose of research work is at the heart of the pragmatist worldview. Tashakkori and Teddlie (2008) are of the view that adopting a pragmatist stance in a research study is how you think such a choice can result in the anticipated or desired outcomes. Similarly, many scholars (Alise & Teddlie, 2010; Creswell, 2014; Mertens, 2010; Morgan, 2014;

Onwuegbuzie & Leech, 2005; Parvaiz, Mufti & Wahab, 2016) agree that adopting a mixed method approach by collecting and analysing data quantitatively and qualitatively to address a research problem, a pragmatist worldview is key. Consistent with this, Parvaiz et al. (2016) are of the view that the pragmatist worldview is the foundation of mixed-method research.

Therefore, in addressing the research topic “influence of teachers’ knowledge on standards-based mathematics curriculum implementation and students’ performance”, the pragmatist worldview of conducting a research study was deemed fit by collecting and analysing data quantitatively and qualitatively.

Research Design

The study employed a mixed-method approach, specifically a sequential explanatory design with a follow-up explanation model variant. Regarding this study, sequential explanatory design occurred in two phases: phase 1 and phase 2 as represented in the diagram in Figure 5. The first phase which borders on quantitative data collection and analysis is the dominant (QUAN), while the second phase on qualitative data collection and analysis is the supplemental (qual).

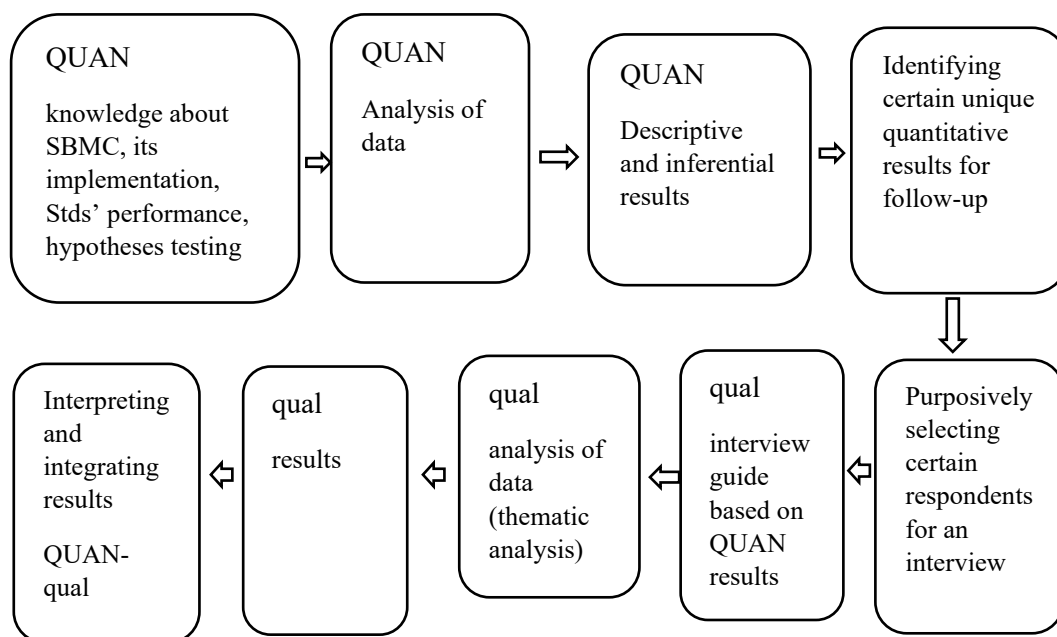


Figure 5: A sequential explanatory design with a follow-up explanation model variant.

Source: Fieldwork, 2023

Concerning the study's design in Figure 5, for the first phase, the researcher collected and analysed quantitative data on teachers' content, pedagogical, pedagogical content and contextual knowledge regarding the standards-based curriculum for mathematics and its implementation. Also, research hypotheses were tested on teachers' knowledge about the standards-based curriculum for mathematics across their demographic characteristics (academic qualification, mode of certificate acquisition and grade levels), its influence on the curriculum's implementation and students' performance. These were executed to examine whether teachers demonstrate low, moderate or high knowledge about the standards-based mathematics curriculum and its implementation. Additionally, to assess statistical differences in teachers' curriculum implementation, if any, across the level of grades they teach, and to establish whether statistical differences exist in teachers' knowledge across their academic qualification, grade levels they teach and mode of acquiring

certificates. Finally, to ascertain whether teachers' knowledge influences their curriculum implementation and students' performance. The descriptive and inferential results were analysed by identifying certain unique quantitative results for follow-up.

The researcher executed the second phase with follow-up explanations based on the unique quantitative results that were obtained regarding extreme scores (either low or high) of knowledge of teachers about the standards-based curriculum for mathematics. Also, based on teachers' implementation (either low or high) of the curriculum. Additionally, it was hinged on statistical differences in teachers' implementation of the curriculum across their grade levels and statistical differences in teachers' knowledge across the levels of grade they teach, academic qualification and mode of acquiring certificates. Similarly, based on the influence of teachers' knowledge on the implementation and students' performance. The researcher needed to have a thorough understanding of the results obtained. Therefore, as argued by Creswell, Plano Clark, Gutmann and Hanson (2003), when you identify "specific quantitative findings such as statistical differences among groups, individuals who scored at extreme levels or unexpected results", is necessary to proceed by collecting qualitative data from those you think can help best explain the findings obtained for expanding or explaining the quantitative results obtained. The researcher selected certain teachers purposively employing an "extreme or deviant case sampling" because the researcher thought such teachers could provide insightful explanations regarding certain unique quantitative results obtained. The teachers' interview guide was designed for this purpose based on the unique

quantitative results that were obtained. The data obtained from the interview guide were analysed thematically as indicated in Figure 5.

After analysing the qualitative results, the researcher integrated and interpreted both quantitative and qualitative results obtained together to have a comprehensive insight into teachers' knowledge about the standards-based curriculum for mathematics and teachers' implementation of the curriculum. In addition, to have a comprehensive understanding of statistical differences in teachers' implementation of the curriculum across their grade levels as well as statistical differences in teachers' knowledge across the levels of grade they teach, academic qualifications, and mode of acquiring certificates. Inferences were drawn from the outcomes. Consistent with Creswell and Plano Clark's (2018) view, when adopting this design, the researcher needs to link quantitative findings to qualitative data collected and also draw inferences after combining the two data sets from the quantitative and qualitative analyses.

Employing a sequential explanatory design has its usefulness. It provides a better understanding of the research problem, especially using qualitative data to explain further initial quantitative results or findings. This is so because researchers can connect data both quantitatively and qualitatively (Creswell & Plano Clark, 2018). In addition, exploring a research problem that gives more focus to a quantitative direction becomes easier. Therefore, in ascertaining the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance, a sequential explanatory design was considered useful.

Notwithstanding the good sides of employing sequential explanatory design, it comes with its challenges. For instance, it requires more time and is

tedious to conduct the two phases of the design. That is, conducting the initial quantitative phase and supplementing it with a qualitative phase. Some researchers (Wilkinson & Staley, 2019) find that sample selection becomes an issue, especially in the qualitative phase, as they argue about how the chosen sample in the qualitative phase would represent the larger sample size in the quantitative phase.

Study Area

The Techiman Municipality, in Ghana's Bono East Region, served as the study's location. Techiman is strategically situated between the Savanna and forest zones of Ghana. It lies in the Western portion of Ghana's Bono East Region. It is the capital of the Techiman Municipality and the Bono East region which was separated from the former Brong-Ahafo Region. Techiman Municipality shares boundaries with four districts/municipalities. It borders Nkoranza South Municipality to the south-east, Techiman North to the north, all in the Bono East Region, Wenchi Municipality (Bono Region) to the north-west, and the south is Offinso North (Ashanti Region). Techiman is a historical town of the Bono Kingdom, whose root is traced from Bono Manso, Amowi and Yefri in the present-day Nkoranza North District.

The Municipality is positioned within latitudes "8° 00' N and 7° 35' S" and longitudes "1° 49' E and 2° 30' W", and has a 669.7km² area of land (Techiman Municipal Assembly, TMA, 2017). It is a leading commercial market centre because it is a place where almost all the major roads from the five northern regions converge. In addition to this, the major roads of Sunyani and Kumasi pass through the city, contributing to its commercial nature in the region and beyond.

It has a total population of 243,335 people comprising 124,636 females and 118, 699 males. Out of the 243, 335 people, 189, 316 are found in urban centres and 54,019 in rural areas (Ghana Statistical Service, GSS, 2021). The data suggests that 48.78 % of the population is male and 51.22 % is female. The females outnumber the males by 2.44% of the total population. Again, the data shows that 77.80% of the population lives in urban centres and only 22.20% in rural areas. Comparing these statistics to other districts and municipalities in the Bono East Region, it is the most populous municipality in the region. Figure 6 presents a map of Techiman Municipality within the Bono East Region. The arrow in Figure 6 points to the location of Techiman Municipality.



Figure 6: A map showing the location of Techiman Municipality within the Bono East Region. Source: Wikipedia

In terms of the population of teachers in basic schools that are public, the Municipality has the highest number of teachers in the region (Bono East Regional Education Directorate, 2022). Considering the populous nature of the Municipality and its strategic position within the Bono East Region, taking a

sample from such an area could represent varied demographics of the teachers concerned.

Population

Regarding this study, the population constitutes public primary teachers and students in the Techiman Municipality. The primary teachers (basic 1 to basic 6) constitute 942 teachers in 101 primary schools (GES, Techiman Municipality, 2022). The primary students are made up of 23133 students (GES, Techiman Municipality, 2022 data for 2nd term), comprising 11386 boys and 11747 girls. Table 1 presents the distribution of the public primary teachers' population in the Techiman Municipality.

Table 1: Population Distribution of Primary Teachers in the Techiman Municipality

Level	No. of Schools	Trained teachers			Untrained teachers			Grand total of trained and untrained teachers		
		M	F	total	M	F	total	M	F	total
Prim.	101	427	501	928	10	4	14	437	505	942

Source: GES Techiman Municipality (2022) data; M=male; F=female

The data in Table 1 reveals that, for the population of 942 public primary teachers in 101 schools, 437 teachers are males representing 46.39%, while 505 teachers are females representing 53.61% of the population. Similarly, female teachers at the primary school level outnumber their male counterparts in the Municipality. This suggests that there are more female teachers in the primary schools in the Techiman Municipality than male teachers. Table 2 presents the

population distribution of students in public primary schools in the Municipality.

Table 2: Population Distribution of Primary Students in the Techiman Municipality

Students' Gender	Freq.	%
Boys	11386	49.22
Girls	11747	50.78
Total	23133	100.00

Source: GES Techiman Municipality (2022) data

The data in Table 2 shows that for the population of 23133 students in public primary schools, 11386 are boys representing 49.22% while 11747 are girls constituting 50.78%. The results reveal that female students outnumber their male counterparts by 1.56%, indicating that there are more female students in the public primary schools than male students.

The population of 942 public primary teachers in 101 schools is further clustered into 11 circuits with a corresponding number of primary schools and teachers as presented in Table 3.

Table 3: Circuits, Number of Schools and Teachers

Circuits	Number of public primary schools	Number of primary Teachers (Basic 1 to Basic 6)
Ahenbronoso	9	91
Techiman South	9	83
Techiman East	12	102
Bamiri	8	85
Nsuta A	9	72

Table 3, Continued

Nsuta B	6	59
Nkwaeso	12	109
Gyarko	8	66
Kenten	7	70
Tanoso	11	95
Techiman West	10	110
Total	101	942

Source: GES Techiman Municipality (2022) data

Table 3 indicates that the minimum number of public primary schools in a circuit is 6 and the maximum is 12. In addition, the minimum number of teachers in a Circuit is 59 and the maximum is 110. This shows that the number of schools and teachers in the various circuits is not distributed evenly. Primary school teachers form the majority of the teachers (942) and have also implemented the standards-based curriculum for a longer period since its implementation in September 2019. Therefore, taking samples from them could represent the public basic school teachers in the Municipality.

Sample and Sampling Procedures

For this study, all 942 teachers from basic 1 to basic 6 were sampled through a census sampling approach in all the 101 public primary schools in the Techiman Municipality. I employed a census sampling approach because I needed every primary teacher within the Techiman Municipality to be involved to better appreciate and have a comprehensive insight into the knowledge of teachers regarding the standards-based curriculum for mathematics, its influence on implementation and students' performance. Again, the population

was small and all the teachers were within the Techiman Municipality. Therefore, it became relevant to include all the primary teachers.

For students, each time a teacher was selected in a particular grade (from basic 1 to basic 6) in a particular school in a circuit, 70% (more than half of the students in a class) of students in the class taught by that particular teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students was calculated to represent students' performance in the class and paired with such teacher's knowledge about the standards-based mathematics curriculum. Where two or more teachers were teaching the same class, the same students' average performance score for the class was used to pair each teacher's knowledge about the standards-based mathematics curriculum. This was to ensure that students taught by a particular teacher were paired with such a teacher to ascertain the influence of such a teacher's knowledge about the standards-based curriculum for mathematics on their students' performance.

Out of the 942 teachers (basic 1 to basic 6 teachers), 33 teachers were sampled for an interview through a purposive sampling technique specifically employing an "extreme (or deviant) case sampling". This was done in order to help provide insightful explanations for some of the unique quantitative findings obtained. Table 4 summarises the sample size and sampling procedures for teachers and students.

Table 4: Sample Size for Teachers, Students and their Justification

Participants	Sample Size	Sampling Technique(s) employed	Procedures	Sample size justification
Teachers (basic 1 to basic 6 teachers)	942	Census sampling	Every primary teacher from the 11 circuits within the municipality was selected and involved in the study.	To better appreciate and have a comprehensive insight into teachers' knowledge about standards-based mathematics curriculum and their implementation.
Students (basic 1 to basic 6 students)	70% of students in a class taught by a teacher	Simple random sampling	Students from basic 1 to basic 6 were selected through simple random sampling.	70% (more than half of the students in a class) of students in the class taught by a particular teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students was calculated to represent students' performance in the class and paired with such teacher's knowledge.
Teachers selected for interview	33	Purposive sampling specifically an extreme (or deviant) case sampling	3 teachers each from the 11 circuits who can provide better explanations for certain quantitative findings obtained were selected purposively.	Aldiabat and Navenec (2018) recommend 16 to 18 interviews to reach data saturation; Lincoln and Guba (1985) cited in Sim, Saunders, Waterfield and Kingstone (2018) recommend 12 to 20 respondents for in-depth personal interviews.

Source: Field Work, 2023

As indicated in Table 4 (p. 141), the sampling procedures for the 942 teachers (basic 1 to basic 6 teachers), 70% (more than half of the students in a class) of students in a class, and 33 teachers for interview are as follows:

Selection Procedures for Teachers

Considering census sampling for this study, every primary teacher from the 11 circuits within the Techiman Municipality in 101 primary schools was selected and involved in the study as presented in Table 5.

Table 5: Sample Size Distribution of Teachers for the Various Circuits

Circuits	Number of primary schools	Number of primary teachers (basic 1 to basic 6)	Sampled teachers (basic 1 to basic 6)
Ahenbronoso	9	91	91
Techiman South	9	83	83
Techiman East	12	102	102
Bamiri	8	85	85
Nsuta A	9	72	72
Nsuta B	6	59	59
Nkwaeso	12	109	109
Gyarko	8	66	66
Kenten	7	70	70
Tanoso	11	95	95
Techiman West	10	110	110
Total	101	942	942

Source: Field Work, 2023

From Table 5, Ahenbrono Circuit had 9 schools and 91 primary teachers; all 91 teachers were selected and involved in the study. Techiman South Circuit had 9 schools and 83 teachers; similarly, all 83 teachers were included. Techiman East Circuit had 12 schools and 102 teachers; all 102

teachers were sampled. The teachers in the remaining circuits were sampled and included in the study using the same criteria. In all, a total of 942 primary teachers were selected through a census procedure for conducting the study. The size of the sample for the teachers ($n = 942$) was appropriate because every primary teacher from basic 1 to basic 6 from the 11 circuits within the Municipality was selected and involved in the study to fully appreciate and have a comprehensive insight into teachers' knowledge about standards-based mathematics curriculum and their implementation.

Selection Procedures for Students

Each time a teacher was sampled from basic 1 to basic 6 in a particular school in a circuit as indicated in Table 5 (see p. 142), 70% (more than half of the students in a class) of students in the class taught by that particular teacher were selected simple randomly using RNG Software and the average performance of such students was calculated to represent students' performance in the class and paired with such teacher's knowledge about the standards-based mathematics curriculum. Where two or more teachers were teaching the same class, the same students' average performance score for the class was used to pair each teacher's knowledge about the standards-based mathematics curriculum. This was to ensure that students taught by a particular teacher were paired with such a teacher to ascertain the influence of such a teacher's knowledge about the standards-based mathematics curriculum on their students' performance.

In using the RNG software to select students in a class taught by a teacher, the lower limit of the RNG was set as 1 and the upper limit was computed to correspond to the total number of students in a class so that each

student had a fair opportunity of being selected without any bias. No duplication of the result was allowed to ensure that a number was not repeated in the process of generating random numbers to select a student. Again, the RNG was computed once and the numbers generated were used to select students in a class.

In all, 942 average performance scores of students in the various schools from basic 1 to basic 6 were used for the analysis. This was reasonable given that a corresponding number of students' average performance scores from basic 1 to basic 6 was needed to pair teachers' knowledge about the standards-based mathematics curriculum with students' performance. Hence, it would be inappropriate to use more students' average performance scores than the teachers' sample size ($n = 942$). Therefore, it became necessary to use the 942 average performance scores of students.

Selection of Teachers for Interview

Out of the 942 teachers (basic 1 to basic 6 teachers) sampled for the study, 33 of the teachers who produced unique results were selected purposively employing an "extreme (or deviant) case sampling" for an interview. The researcher chose an "extreme (or deviant) case sampling" because teachers who demonstrated unique results needed to be contacted again to gain an insightful explanation for such unique quantitative results. The procedures for selection are presented in Table 6.

Table 6: Sample of Teachers Selected for the Interview

Circuits	Number of primary schools	Number of primary teachers (basic 1 to basic 6)	Sampled teachers for the interview
Ahenbronoso	9	91	3
Techiman South	9	83	3
Techiman East	12	102	3
Bamiri	8	85	3
Nsuta A	9	72	3
Nsuta B	6	59	3
Nkwaeso	12	109	3
Gyarko	8	66	3
Kenten	7	70	3
Tanoso	11	95	3
Techiman West	10	110	3
Total	101	942	33

Source: Field Work, 2023

From Table 6, 3 teachers from each of the 11 circuits were purposively selected employing “extreme (or deviant) case sampling”. Teachers who could help provide insightful explanations regarding the unique quantitative results obtained were chosen. The unique quantitative results were based on teachers’ knowledge (either low or high) about the standards-based curriculum for mathematics. Also, teachers’ implementation (either low or high) of the curriculum. Additionally, statistical differences in teachers’ curriculum implementation across the grade levels they teach. Finally, statistical differences in teachers’ knowledge about the standards-based curriculum for mathematics across their academic qualifications, grade levels they teach, and the mode of acquiring their certificates.

In the Ahenbronoso circuit, 3 teachers were purposively selected. In the Techiman South circuit, 3 teachers were also purposively chosen. In the remaining circuits as indicated in Table 6 (see p. 145), similarly, 3 teachers were purposively picked in each circuit. Creswell et al. (2003) maintain that, in a follow-up to gather qualitative data in explaining or expanding certain unique quantitative results obtained, relying on respondents who could help provide insightful explanations is essential. Therefore, it became necessary to select teachers who demonstrated unique results. In all, a total of 33 teachers were chosen for the interview section. The sample for the interview ($n = 33$) was appropriate in the sense that as recommended by Aldiabat and Navenec (2018), to reach data saturation you need 16 to 18 interviews. Similarly, Lincoln and Guba (1985) as cited in Sim, Saunders, Waterfield and Kingstone (2018) recommend 12 to 20 respondents for in-depth personal interviews. Hence, selecting 33 teachers for the interview was deemed fit.

Data Collection Instruments

In this mixed-method study, various methods were adopted for data collection. A questionnaire, interview and test were employed for data collection.

Questionnaire

A self-designed Teachers' Knowledge about the Standards-based Mathematics Curriculum Questionnaire (TKSBMCQ) was developed manually (see Appendix A). The questionnaire (TKSBMCQ) items were generated from the standards-based curriculum for mathematics at the lower (B1-B3) and upper primary (B4 -B6), NPECF (2018), NTECF (2017), as well as the reviewed

literature. The TKS BMCQ items were closed-ended except for two items on the demographics that were open-ended.

The researcher employed a questionnaire to assess teachers' knowledge because numerous studies (Asamoah-Gyimah, 2022; Awadh et al., 2014; Dunn et al., 2016; Gupta, Mehta, Gupta, Arora, & Setia, 2015; Hassali et al., 2013; Kainga et al., 2022; Karuniawati et al., 2021; Pande et al., 2000; Roy, Ghosh, Saha, & Sarker, 2020; Twinamasiko et al., 2021; Wagner, Lacey, Chyun, & Abbott, 2005) have widely utilised a questionnaire, particularly when assessing knowledge, attitudes and practice (KAP survey). In the aforementioned studies, a questionnaire was employed to assess knowledge by categorising response options for each item into "yes/no/I do not know" or "true/false/I do not know" where a correct response (yes or true response) was assigned a score of 1 and an incorrect response (no/false/I do not know) awarded a score of 0. In line with this, the TKS BMCQ was deemed appropriate to assess teachers' knowledge about the standards-based curriculum for mathematics.

The TKS BMCQ was partitioned into six sections from section A to section F. Section A sought information on teachers' demographic characteristics which include gender, years of experience in teaching, age in years, academic qualification, mode of certificate acquisition and grade level taught. Section B sought information on teachers' content knowledge about the standards-based curriculum for mathematics which answers research question one. Also, Section C sought information on teachers' pedagogical knowledge about the curriculum which addresses research question two. Similarly, Section D sought information on teachers' pedagogical content knowledge about the curriculum which answers research question three. Section E sought

information on teachers' contextual knowledge about the curriculum which addresses research question four. Section F on the other hand, sought information on teachers' implementation of the curriculum which addresses research question five.

To assess teachers' knowledge, the response options for the items in Sections B, C, D and E of the TKS BMCQ were categorised into "true", "false" or "not sure". A "True" response indicates knowledge of the concept with a score of 1. Both "false" and "not sure" options were considered as a lack of knowledge of the concept and scored 0. Also, Section F assesses teachers' standards-based mathematics curriculum implementation. The scores for response options of items were based on a Likert scale of 5-points where "never" attracted a score of 0, "almost never" has a score of 1, "occasionally" with a score of 2, "almost every time" has a score of 3, and "every time" with a score of 4. This is consistent with many studies (Aarons, Ehrhart & Farahnak, 2014; Hartveit et al., 2019; Mettert, Lewis, Dorsey, Halko & Weiner, 2020; Peters, Borge, Skar & Egeland, 2022) that have assessed implementation.

In Section A, 6 items were set comprising both closed and open-ended items to gather data on teachers' demographic information. Sections B, C, D and E on teachers' content, pedagogical, pedagogical content and contextual knowledge respectively, had 4 closed-ended items for each sub-dimension. Similarly, Section F on teachers' curriculum implementation had 4 closed-ended items for each sub-dimension, except for the sub-dimension of teachers' implementation of organisation and structure of the curriculum which had 2 closed-ended items.

Teachers' Interview Guide

A semi-structured and open-ended Teachers' Interview Guide (TIG) was designed (see Appendix B) to further interrogate the unique quantitative results obtained. The Teachers' Interview Guide (TIG) was a self-developed instrument. The items were generated based on the unique quantitative results obtained. It was divided into two sections. The first section indicates the pseudonym of an interviewee (teacher), school, date and duration of the interview. The second section consists of 6 open-ended questions which were based on the unique quantitative results obtained.

From research question 5 which sought to examine basic school teachers' implementation of the standards-based mathematics curriculum, the researcher found teachers' low implementation of ICT which was extreme compared to other implementations of the curriculum. Therefore, a question was set to further enquire what could account for teachers' low implementation of ICT regarding the standards-based mathematics curriculum in the various classrooms.

Also, hypothesis one (1), which sought to examine whether there was any statistically significant difference in teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum across their academic qualification, mode of certificate acquisition and grade levels when the effects of their years of experience in teaching, age and gender are controlled for, the researcher found a statistically significant difference in teachers' knowledge about the standards-based mathematics curriculum across their grade levels. The findings indicate a difference in teachers' knowledge of the standards-based mathematics

curriculum across teachers in Basic 1, 2, 3, 4, 5 and 6. Therefore, a question was set to further interrogate what could account for differences in teachers' knowledge about the standards-based mathematics curriculum in Basic 1, 2, 3, 4, 5 and 6.

Again, hypothesis two (2), which sought to examine whether there was any statistically significant difference in teachers' standards-based mathematics curriculum implementation across their grade levels when the effects of their years of experience in teaching, age and gender are controlled for, the researcher found a statistically significant difference in teachers' standards-based mathematics curriculum implementation across their grade levels. The findings indicate a difference in teachers' implementation of the standards-based mathematics curriculum across teachers in Basic 1, 2, 3, 4, 5, and 6. Therefore, a question was set to further enquire what could account for differences in teachers' implementation of the standards-based mathematics curriculum in Basic 1, 2, 3, 4, 5, and 6.

The researcher employed an interview guide to gain a comprehensive insight into these unique quantitative results. In line with many scholars' views (Alamri, 2019; Monday, 2020), employing an interview allows a researcher to explore responses given by respondents in detail where other methods such as a questionnaire, test and observation cannot be utilised. Therefore, to probe further into the unique quantitative results obtained, the Teachers' Interview Guide (TIG) was deemed relevant for explaining and expanding these unique results. That is, low implementation of ICT, differences in teachers' knowledge and implementation of the curriculum.

Students' Mathematics Performance Test

A structured and closed-ended Students' Mathematics Performance Test (SMPT) was adapted (see Appendix C) from the Techiman Municipal Education Directorate's end of the second term (2021/2022 academic year) examination test items for basic 1 to basic 6 to assess students' mathematics performance. The test was employed because the researcher wanted to understand how learners had grasped mathematics taught by their teachers using the standards-based mathematics curriculum. In line with Adom, Mensah and Dake's (2020) view, a test is useful in determining students' capacity to carry out a task or show mastery of a concept. It also ensures an objective way of checking and evaluating students' knowledge and skills (Halova & Kobilarov, 2010). Hence, in assessing students' mathematics performance, the Students' Mathematics Performance Test (SMPT) was considered relevant. These data were collected to statistically test the influence of teachers' knowledge about the standards-based mathematics curriculum on students' academic performance.

The items and response options from the Municipal Education Directorate's test items were modified. This was done to reduce students' familiarity with the items and responses and also to ensure that students do not have a clue about the answers since the items were taken from the end of the second term (2021/2022 academic year) examination test items. Initially, the response options of each item were arranged in A, B, C and D formats. The response options were modified into "true", "false" or "not sure" options. "True" indicates the correct response with a score of 1. Both "false" and "not sure" options were considered incorrect and scored 0.

The Students' Mathematics Performance Test (SMPT) for Basic 1 to Basic 6 was divided into two sections (Sections A and B). Section A sought demographic information on students' age. The selected students' average age was calculated and used to represent the students' age in a class. Students' demographics (such as sex and whether students receive extra tuition from home) whose average cannot be calculated were excluded. This was because 70% (more than half of the students in a class) of students in a class taught by a teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students was calculated to represent students' performance in a class and paired with a teacher's knowledge about the standards-based mathematics curriculum. Therefore, representing a class with "an average sex and an average of whether students receive extra tuition from home" was impossible since an average of these demographics could not be estimated to represent a class, hence their exclusion from the demographics. Section B sought information on students' mathematics performance which consisted of 20 items with "true", "false" or "not sure" as response options. The "true" option indicates the correct response with a score of 1. Both "false" and "not sure" options were regarded as incorrect and awarded a score of 0.

Pilot Testing of Data Collection Instruments

For the researcher to check how valid and reliable and also to revise the instruments, Techiman North District was chosen for pilot testing the instruments. The Teachers' Knowledge about the Standards-based Mathematics Curriculum Questionnaire (TKSBMCQ) and Students' Mathematics Performance Test (SMPT) were pilot tested with teachers and students respectively. Techiman North District was chosen because teachers and students

in the district possessed comparable qualities to the teachers and students in the Techiman Municipality due to their similar geographical location.

Before piloting the instrument, the researcher visited the teachers and students during their normal school hours from 8:00 am to 2:30 pm to seek their consent. The researcher administered an Informed Consent Form to the teachers and students to seek their consent. The researcher introduced himself to them and explained the purpose of the study and the need for their involvement. However, they were informed that taking part in the pilot testing of the instruments was voluntary. It was explained to them the procedures for answering the instruments. Again, they were made aware that in case they agreed to take part in the pilot testing process by answering the instruments, the risks and discomfort they may encounter were minimal. Further, they were assured that any information they would offer would be protected and kept confidential, and their identities would not be revealed to anyone. After their acceptance to participate in the pre-testing of the instruments, the researcher started with the pilot testing of the instruments.

The researcher pilot tested the TKSBMCQ with 96 teachers from basic 1 to basic 6. The teachers were selected using the procedures described in Tables 3, 4 and 5 (see p. 138-142). The time it took to answer the TKSBMCQ was 25 to 30 minutes. This occurred within the allotted time. Hence, the time allowed for the main study was not changed. The reliability of the TKSBMCQ was estimated using Cronbach's Alpha reliability coefficient and composite reliability (rho-c). Also, the construct validity of the TKSBMCQ was estimated using SmartPLS 4. Before this, in addressing the face and content validity of the TKSBMCQ, a face and content validity form (see Appendix D) was

developed based on Oluwatayo's (2012) and Patel and Desai's (2020) criteria which assessed grammar appropriateness, the items' unambiguity and clarity, right word spelling, correct construction of sentences, appropriateness of items' difficulty level and items' relevance for the construct. The researcher gave the face and content validity form to 2 raters who were experts in rating the TKSBMCQ. The ratings were based on "yes" and "no" responses to each item of the TKSBMCQ where a "yes" response attracted a score of 1 and a "no" response awarded a score of 0. A "yes response" meant that the rater agreed that each item was in line with the above criteria, while a "no response" meant the rater was not in agreement that each item was in line with the above criteria. The 2 raters' agreement level was estimated using Cohen's Kappa Coefficient.

The researcher pilot tested the SMPT with 96 students from basic 1 to basic 6. For each of the 6 basic levels (Basic 1 to Basic 6) in primary school, 16 students were chosen through a simple random procedure by employing RNG software which summed up to 96 students. It took students 15 to 20 minutes to answer the SMPT. This was within the anticipated time set for the test. Hence, the time allocated for the main study was not revised. The reliability of the SMPT was estimated using a split-half method by estimating the Spearman-Brown correlation coefficient. The items were split into odd-number items and even-number items and the Spearman-Brown correlation coefficient was estimated.

Prior to this, in checking the face and content validity of the SMPT, a face and content validity form (see Appendix E) was developed based on Oluwatayo's (2012) and Patel and Desai's (2020) criteria to check grammar appropriateness, the items' unambiguity and clarity, right word spelling, correct

construction of sentences, appropriateness of items' difficulty level and items' relevance for the test. The researcher gave the face and content validity form to 2 raters who were experts in rating the SMPT. Each item on the SMPT was rated using "yes" and "no" responses, where a "yes" response was scored 1 and a "no" response with a score of 0. A "yes" response indicated that the rater agreed that each item met the aforementioned requirements, whereas a "no" response indicated that the rater disagreed that each item met the aforementioned criteria. Using Cohen's Kappa Coefficient, the 2 raters' agreement level was calculated.

The Teachers' Interview Guide (TIG) was pilot tested later. After obtaining certain unique quantitative results from the first phase of the quantitative analysis, the researcher developed TIG (see Appendix B) for further probing into such unique results. The researcher conveniently selected 7 teachers who were not part of the 33 teachers to be interviewed and pilot tested the TIG with them. This was done to check the appropriateness of the time allocated for the interview section. Each teacher was interviewed for 25 to 30 minutes, instead of the anticipated time of 20 to 25 minutes. This made it possible to revise the initial time allocated for interviewing each teacher.

Prior to this, in checking the face and content validity of the TIG, a face and content validity form was developed (see Appendix F) based on Oluwatayo's (2012) and Patel and Desai's (2020) criteria which addressed grammar appropriateness, the items' unambiguity and clarity, right word spelling, correct construction of sentences, appropriateness of items' difficulty level and items' relevance for the interview. The researcher gave the face and content validity form to 2 raters who were experts in rating the TIG. Each item on the TIG was rated using "yes" and "no" responses where a "yes" response

attracted a score of 1 and a “no” response awarded a score of 0. Each time the rater responded with a "yes," it meant each item met the aforementioned requirements, however, each time the rater responded with a "no," it meant disagreement. Cohen's Kappa Coefficient was used to calculate how well the two raters agreed.

Validity and Reliability of Data Collection Instruments

In light of the pilot testing, the validity and reliability test results of the TKSBMCQ, SMPT and TIG are reported as follows: For the TKSBMCQ, Cohen's Kappa Coefficient (κ) of the 2 expert raters demonstrates a significant outstanding agreement, [$\kappa = .91$, $SE = .08$, 95% CI, (0.75, 1.06), $p < .001$] for the face and content validity check. Adopting Landis and Koch's (1977) criteria, Cohen's Kappa Coefficient (κ) less than ($<$) 0 was regarded as poor agreement; 0.0 to 0.20 was considered as slight agreement; 0.21 to 0.40 was viewed as fair agreement; 0.41 to 0.60 was regarded as moderate agreement; 0.61 to 0.80 was acceptable as substantial agreement and $\kappa \geq 0.81$ was regarded as outstanding agreement. Hence, the result obtained shows the 2 expert raters' agreement level for judging the face and content validity of the TKSBMCQ was excellent. Further, the construct validity and reliability of the TKSBMCQ were checked. The results obtained are reported in Tables 7, 8, 9 and 10 and Figures 7, 8, 9, 10 and 11.

Table 7: Construct Validity and Reliability Test of Sub-dimensions of the TKSBMQC Addressing Content Knowledge (CK)

KD	Sub	Item	Loadings	P	AVE	α	C R	HTMT
Content Knowledge	KOSC	Q1	.87	.000	.76	.89	.92	KOSC & KELB .62
		Q2	.88	.000				KOSC & KIEC .77
		Q3	.89	.000				KOSC & KCC .48
		Q4	.83	.000				
	KELB	Q5	.85	.000	.75	.88	.92	KELB & KIEC .62
		Q6	.90	.000				KELB & KCC .75
		Q7	.90	.000				KELB & KOSC .62
		Q8	.79	.000				
	KIEC	Q9	.71	.000	.74	.88	.91	KIEC & KCC .63
		Q10	.91	.000				KIEC & KOSC .77
		Q11	.90	.000				KIEC & KELB .62
		Q12	.88	.000				
	KCC	Q13	.84	.000	.79	.91	.94	KCC & KOSC .48
		Q14	.92	.000				KCC & KELB .75
		Q15	.92	.000				KCC & KIEC .63
		Q16	.88	.000				

Source: Field Work, 2023. KD = Knowledge Domain; AVE = Average Variance Extracted; α = Cronbach's alpha; CR = Composite reliability; HTMT = Heterotrait-monotrait ratio; KOSC = Knowledge about organisation and structure of the curriculum; KELB = Knowledge of expected learning behaviour; KIEC = Knowledge of instructional expectations about the curriculum; KCC = Knowledge of the core competencies

The results in Table 7 show that for each sub-dimension: Knowledge about the organisation and structure of the curriculum (KOSC), Knowledge of expected learning behaviour (KELB), Knowledge of instructional expectations about the curriculum (KIEC) and Knowledge of the core competencies (KCC) assessing content knowledge, item loadings for each item were found above the acceptable threshold (> 0.70) (Gefen, Straub & Boudreau, 2000; Kim, Ku, Kim,

Park & Park, 2016) and significant ($p < .001$) as well indicating that each item measures a particular sub-dimension well. Hence, no item was removed. Further, the Average Variance Extracted (AVE) values for KOSC (AVE = .76), KELB (AVE = .75), KIEC (AVE = .74), and KCC (AVE = .79) were above 0.50 (AVE > .50) threshold (Bagozzi & Yi, 1988; Fornell & Larcker, 1981), indicating good convergent validity. This indicates that, for each sub-dimension, all the items come together to measure it.

To assess the discriminant validity, the Heterotrait-Monotrait ratio (HTMT) was checked. Henseler, Ringle and Sarstedt (2015) are of the view that the Heterotrait-Monotrait ratio (HTMT) of correlations is more robust than Fornell and Larcker's (1981) criterion when addressing discriminant validity. The discriminant validity for KOSC and KELB (HTMT = .62), KOSC and KIEC (HTMT = .77), KOSC and KCC (HTMT = .48), KELB and KIEC (HTMT = .62), KELB and KCC (HTMT = .75), and KIEC and KCC (HTMT = .63) was found within the acceptable threshold of HTMT < .90 (Henseler et al., 2015), indicating that each sub-dimension addresses a different issue. Assessing the reliability of each sub-dimension, the Cronbach alpha value ($\alpha = .89$) and composite reliability (CR = .92) for KOSC, Cronbach alpha value ($\alpha = .88$) and composite reliability (CR = .92) for KELB, Cronbach alpha value ($\alpha = .88$) and composite reliability (CR = .91) for KIEC, and Cronbach alpha value ($\alpha = .91$) and composite reliability (CR = .94) for KCC were found to be more than the minimum limit of 0.70 (Hair, Celsi, Money, Samouel & Page, 2016; Hair, William, Babin & Anderson, 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This indicates that the various sub-dimensions measuring content knowledge show excellent internal consistency and are reliable. Figure

7 shows a graphical representation of item loadings, AVE and correlations of sub-dimensions addressing content knowledge.

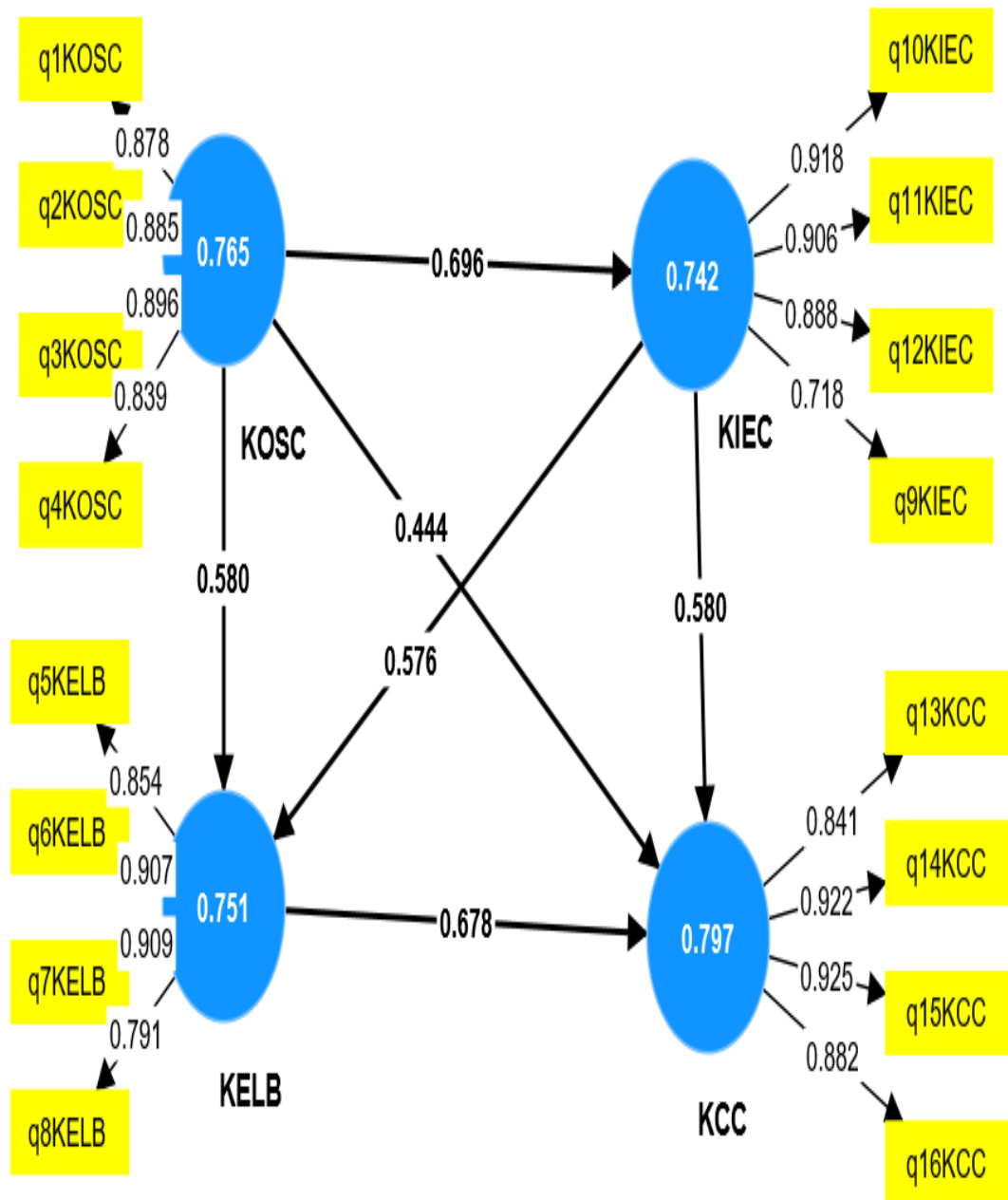


Figure 7: Item Loadings of sub-dimensions addressing content knowledge

Source: Field Work, 2023

Regarding the construct validity and reliability of the TKSBMCQ, Table 8 presents items assessing pedagogical knowledge.

Table 8: Construct Validity and Reliability Test of Sub-dimensions of the TKSBMQC Addressing Pedagogical Knowledge (PK)

KD	Sub	Item	Loadings	P	AVE	α	CR	HTMT
PK	KLCP	Q17	.79	.000	.68	.84	.89	KLCP & KIEP .81
		Q18	.88	.000				KLCP & KDSP .75
		Q19	.88	.000				KLCP & KICTPT .88
	KIEP	Q20	.74	.000				
		Q21	.85	.000	.75	.89	.92	KIEP & KDSP .88
		Q22	.90	.000				KIEP & KICTPT .83
		Q23	.90	.000				KIEP & KLCP .81
	KDSP	Q24	.81	.000				
		Q25	.79	.000	.81	.92	.94	KDSP & KICTPT .77
		Q26	.94	.000				KDSP & KLCP .75
		Q27	.95	.000				KDSP & KIEP .88
	KICTPT	Q28	.91	.000				
		Q29	.89	.000	.80	.91	.94	KICTPT & KLCP .88
		Q30	.93	.000				KICTPT & KIEP .83
		Q31	.93	.000				KICTPT & KDSP .77
		Q32	.82	.000				

Source: Field Work, 2023. KD = Knowledge Domain; AVE = Average Variance Extracted; α = Cronbach's alpha; CR = Composite reliability; HTMT = Heterotrait-monotrait ratio; KLCP = Knowledge of learner-centred pedagogy; KIEP = Knowledge of inclusion and equity pedagogy; KDSP = Knowledge of differentiation and scaffolding pedagogy; KICTPT = Knowledge of ICT as a pedagogical tool

The results in Table 8 show that for each sub-dimension: Knowledge of learner-centred pedagogy (KLCP), Knowledge of inclusion and equity pedagogy (KIEP), Knowledge of differentiation and scaffolding pedagogy (KDSP), and Knowledge of ICT as a pedagogical tool (KICTPT) addressing pedagogical knowledge, item loadings for each item were significant ($p < .001$) and above the minimum threshold of 0.70 (> 0.70) (Gefen, Straub & Boudreau,

2000; Kim et al., 2016). This suggests that each item measures a particular sub-dimension well. Hence, no item was removed. The Average Variance Extracted (AVE) values for KLCP (AVE = .68), KIEP (AVE = .75), KDSP (AVE = .81) and KICTPT (AVE = .80) were above 0.50 (AVE >.50) threshold (Bagozzi & Yi, 1988; Fornell & Larcker, 1981), implying good convergent validity. This shows that, for each sub-dimension, all the items combine to measure it well.

To address the discriminant validity, Heterotrait-Monotrait ratio (HTMT) values for KLCP and KIEP (HTMT = .81), KLCP and KDSP (HTMT = .75), KLCP and KICTPT (HTMT = .88), KIEP and KDSP (HTMT = .88), KIEP and KICTPT (HTMT = .83), and KDSP and KICTPT (HTMT = .77) were found within the acceptable limit of HTMT < .90 (Henseler et al., 2015). This demonstrates that each sub-dimension deals with a different issue. Checking the reliability of each sub-dimension, the Cronbach alpha value (α = .84) and composite reliability (CR = .89) for KLCP, Cronbach alpha value (α = .89) and composite reliability (CR = .92) for KIEP, Cronbach alpha value (α = .92) and composite reliability (CR = .94) for KDSP, and Cronbach alpha value (α = .91) and composite reliability (CR = .94) for KICTPT were found to be higher than the minimum limit of 0.70 (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This implies that items for the various sub-dimensions addressing pedagogical knowledge demonstrate excellent internal consistency and are reliable. Figure 8 displays a graphical format of item loadings, AVE and correlations of sub-dimensions addressing pedagogical knowledge.

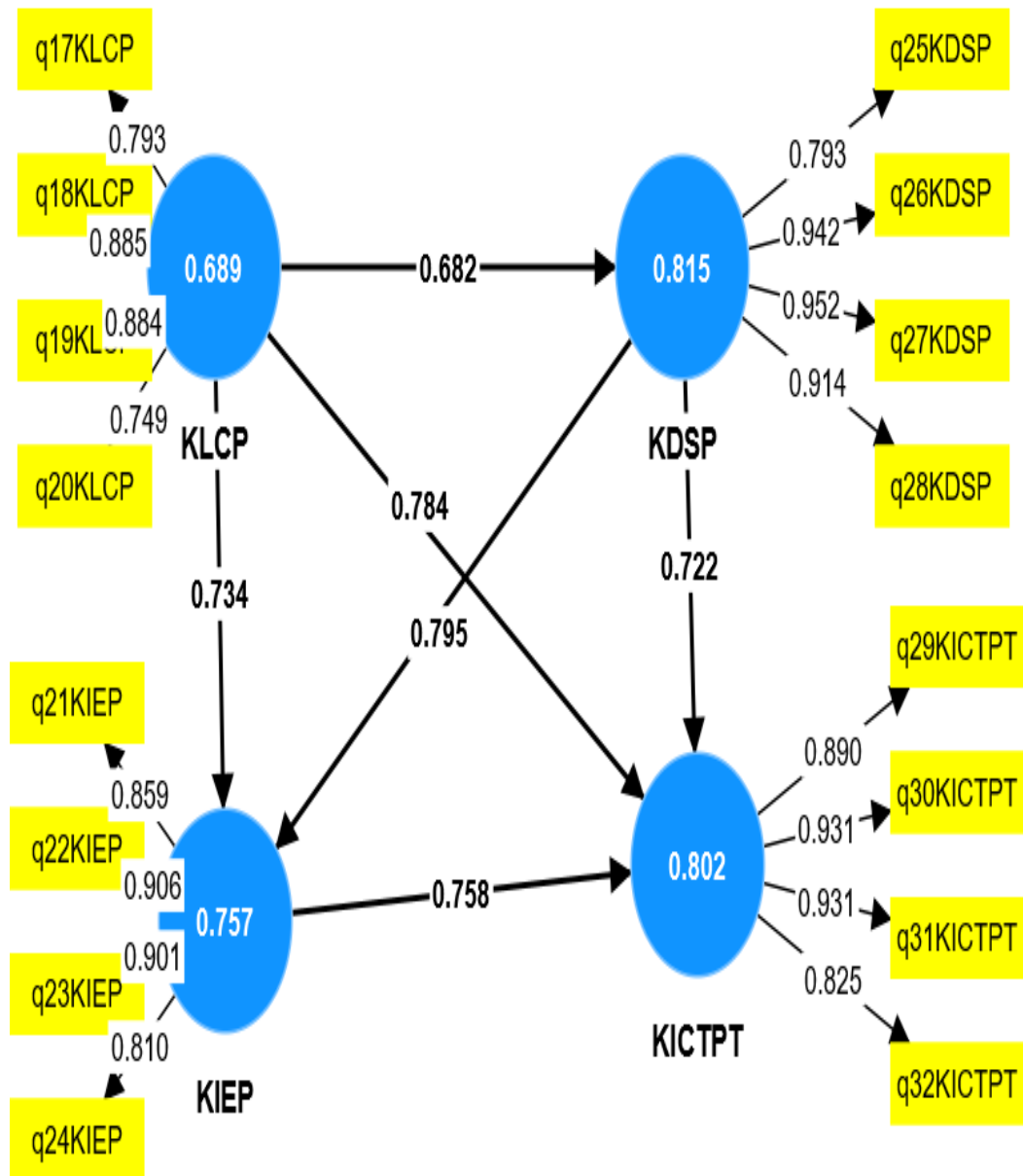


Figure 8: Item Loadings of sub-dimensions addressing pedagogical knowledge

Source: Field Work, 2023

Concerning the construct validity and reliability of the TKS BMCQ, Table 9 presents items assessing pedagogical content and contextual knowledge.

Table 9: Construct Validity and Reliability Test of Sub-dimensions of the TKS BMCQ Addressing Pedagogical Content Knowledge (PCK) and Contextual Knowledge (CtK)

KD	Sub	Item	Loadings	P	AVE	α	CR	HTMT
PCK	KLL	Q33	.81	.000	.75	.89	.92	KLL & KRAP .90
		Q34	.87	.000				
		Q35	.92	.000				
		Q36	.86	.000				
		Q37	.87	.000	.82	.93	.95	KRAP & KLL .90
	KRAP	Q38	.93	.000				
		Q39	.94	.000				
		Q40	.87	.000				
		Q41	.82	.000	.77	.90	.93	KLC & KL .82
		Q42	.92	.000				
CtK	KLC	Q43	.93	.000				
		Q44	.84	.000				
		Q45	.88	.000	.84	.94	.95	KL & KLC .82
		Q46	.94	.000				
	KL	Q47	.95	.000				
		Q48	.90	.000				

Source: Field Work, 2023. KD = Knowledge Domain; AVE = Average Variance Extracted; α = Cronbach's alpha; CR = Composite reliability; HTMT = Heterotrait-monotrait ratio; KLL = Knowledge of learners' learning; KRAP = Knowledge of recommended assessment practices; KLC = Knowledge of learning contexts (classroom, school, community and culture); KL = Knowledge of the Learner

The results in Table 9 show that for each sub-dimension: knowledge of learners' learning (KLL) and Knowledge of recommended assessment practices (KRAP) addressing pedagogical content knowledge, item loadings for each item were found significant ($p < .001$) and above the minimum threshold (> 0.70) (Gefen, Straub & Boudreau, 2000; Kim et al., 2016). This means that each item measures a particular dimension well. Hence, none of the items were removed. The Average Variance Extracted (AVE) values for KLL (AVE = .75) and KRAP (AVE = .82) were above the minimum limit of 0.50 (AVE $> .50$) (Bagozzi & Yi, 1988; Fornell & Larcker, 1981), suggesting good convergent

validity. This implies that, for each sub-dimension, all the items come together to measure it well.

For discriminant validity, the Heterotrait-Monotrait (HTMT) ratio value for KLL and KRAP (HTMT = .90) was within the threshold value of .90 (Franke & Sarstedt, 2019; Henseler et al., 2015), implying that each sub-dimension measures a different issue. In checking the reliability of each sub-dimension, the Cronbach alpha value ($\alpha = .89$) and composite reliability (CR = .92) for KLL and Cronbach alpha value ($\alpha = .93$) and composite reliability (CR = .95) for KRAP were found to be more than the minimum limit of 0.70 (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994) indicating that items for the various sub-dimensions addressing pedagogical content knowledge have excellent internal consistency and are reliable. Figure 9 presents a graphical representation of item loadings, AVE and correlations of sub-dimensions assessing pedagogical content knowledge.

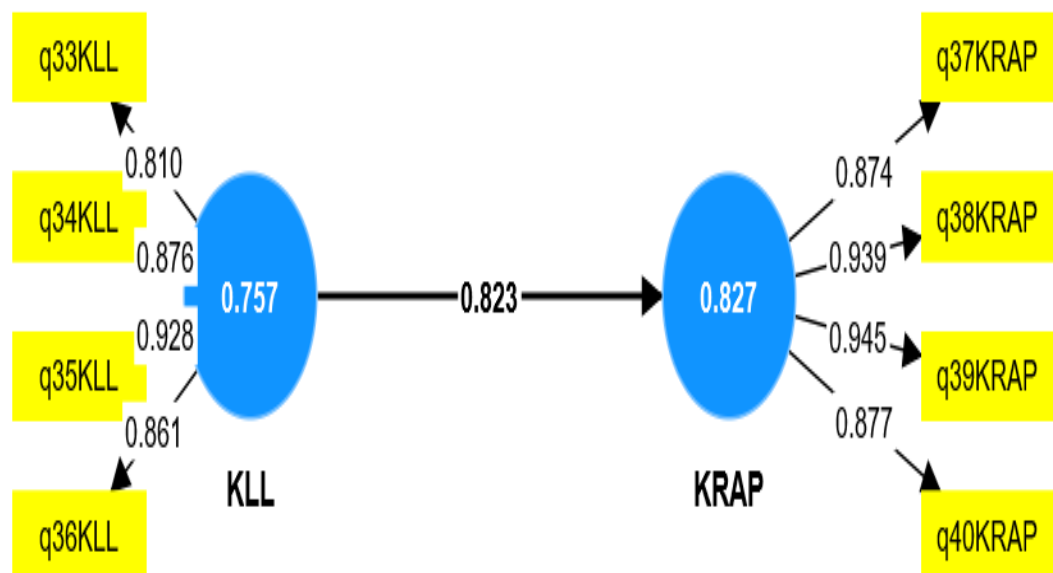


Figure 9: Item Loadings of sub-dimensions addressing pedagogical content knowledge

Source: Field Work, 2023.

On sub-dimensions addressing contextual knowledge, the item loadings of each item for knowledge of learning contexts (KLC) and knowledge of the learner (KL) were found significant ($p < .001$) and above the minimum threshold of 0.70 ($>.70$), suggesting that each item measures a particular sub-dimension well. Hence, no item was removed. The Average Variance Extracted for KLC (AVE = .77) and KL (AVE = .84) were found above the minimum limit of 0.50 (AVE $>.50$) (Bagozzi & Yi, 1988; Fornell & Larcker, 1981), indicating good convergent validity. This shows that all items of each sub-dimension combine to measure it well. For discriminant validity, the Heterotrait-Monotrait (HTMT) ratio value for KLC and KL (HTMT = .82) was found within the acceptable range, suggesting that each sub-construct assesses a different issue.

Addressing the reliability of each sub-dimension, the Cronbach alpha value ($\alpha = .90$) and composite reliability (CR = .93) for KLC and Cronbach alpha value ($\alpha = .94$) and composite reliability (CR = .95) for KL were found above the minimum threshold of 0.70 (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This implies that items for the various sub-dimensions assessing contextual knowledge have excellent internal consistency and are reliable. Figure 10 provides a graphical representation of item loadings, AVE and correlations of sub-dimensions addressing contextual knowledge.

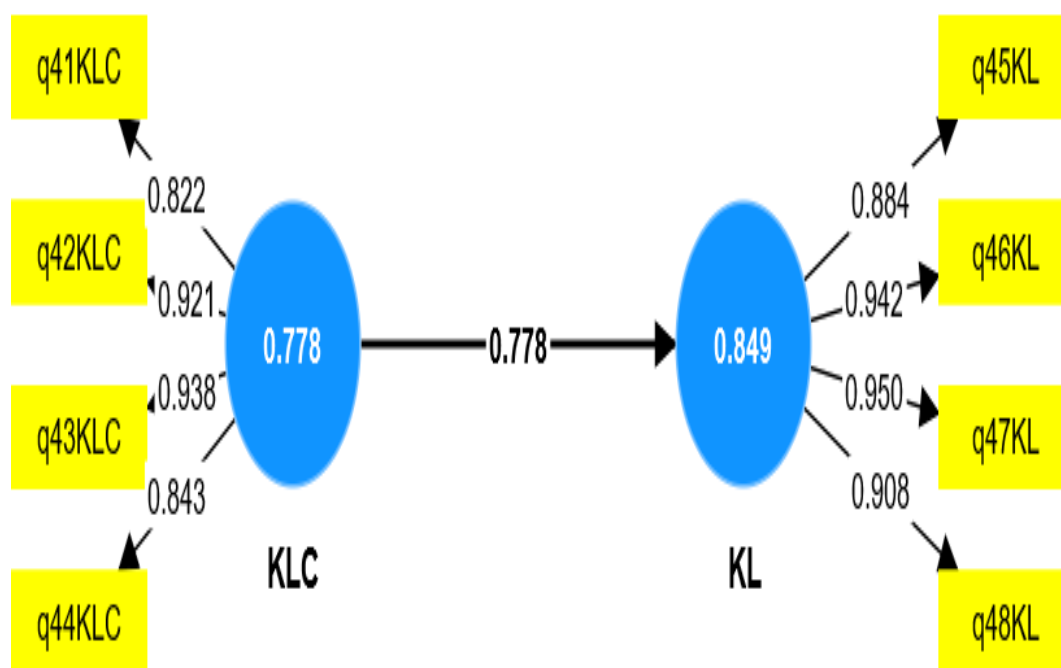


Figure 10: Item Loadings of sub-dimensions addressing contextual knowledge

Source: Fieldwork, 2023

Further, combining items of the various sub-dimensions to address each of the content, pedagogical, pedagogical content and contextual knowledge, construct validity and reliability were checked. The results obtained are presented in Table 10.

Table 10: Construct Validity and Reliability Test of all Sub-dimensions Addressing Content, Pedagogical, Pedagogical Content and Contextual Knowledge

KD	Item	Loadings	P	AVE	α	CR	HTMT
CK	Q1	.65	.000	.52	.93	.94	CK& PK .74
	Q2	.63	.000				CK&PCK .56
	Q3	.65	.000				CK& CtK .48
	Q4	.74	.000				
	Q5	.79	.000				
	Q6	.71	.000				
	Q7	.71	.000				
	Q8	.66	.000				
	Q9	.76	.000				
	Q10	.69	.000				
	Q11	.69	.000				
	Q12	.75	.000				

Table 10, Continued

	Q13	.75	.000				
	Q14	.76	.000				
	Q15	.77	.000				
	Q16	.74	.000				
PK	Q17	.67	.000	.61	.95	.96	PK& CK .74
	Q18	.75	.000				PK& PCK .68
	Q19	.70	.000				PK & CtK .63
	Q20	.76	.000				
	Q21	.80	.000				
	Q22	.83	.000				
	Q23	.81	.000				
	Q24	.71	.000				
	Q25	.70	.000				
	Q26	.78	.000				
	Q27	.86	.000				
	Q28	.86	.000				
	Q29	.80	.000				
	Q30	.84	.000				
	Q31	.84	.000				
	Q32	.77	.000				
PCK	Q33	.77	.000	.72	.94	.95	PCK& CK .56
	Q34	.81	.000				PK& PK .68
	Q35	.88	.000				PK & CtK .74
	Q36	.83	.000				
	Q37	.83	.000				
	Q38	.87	.000				
	Q39	.89	.000				
	Q40	.87	.000				
CtK	Q41	.76	.000	.71	.94	.95	CtK & CK .48
	Q42	.85	.000				CtK & PK .63
	Q43	.86	.000				CtK& PCK .74
	Q44	.84	.000				
	Q45	.87	.000				
	Q46	.85	.000				
	Q47	.88	.000				
	Q48	.82	.000				

Source: Fieldwork, 2023. KD = Knowledge Domain; AVE = Average Variance Extracted; α = Cronbach's alpha; CR = Composite reliability; HTMT = Heterotrait-monotrait ratio; CK = Content knowledge; PK = Pedagogical knowledge; PCK = Pedagogical content knowledge; CtK = Contextual knowledge

The results in Table 10 show that, combining the 16 items to address content knowledge (CK), item loadings for each item were found above the minimum limit of 0.70 (> 0.70) (Gefen, Straub & Boudreau, 2000; Kim et al., 2016) and significant ($p < .001$) as well except for items Q1 (= .65), Q2 (= .63),

Q3 (= .65), Q8 (= .66), Q10 (= .69) and Q11(= .69). However, since the overall Average Variance Extracted (AVE) of the 16 items was 0.52 above the minimum threshold of 0.50 ($AVE > 0.50$) (Bagozzi & Yi, 1988; Fornell & Larcker, 1981), items Q1, Q2, Q3, Q8, Q10 and Q11 were included. The AVE value of 0.52 demonstrates that all the items combine to measure content knowledge, indicating good convergent validity. For discriminant validity, the Heterotrait-Monotrait ratio (HTMT) values for CK and PK ($HTMT = .77$), CK and PCK ($HTMT = .56$), and CK and CtK ($HTMT = .48$) were found within the acceptable limit of $HTMT < .90$ (Henseler et al., 2015). This implies that each of the CK, PK, PCK and CtK constructs measures different issues. The Cronbach alpha value ($\alpha = .93$) and composite reliability ($CR = .94$) for CK were found to be higher than the minimum limit of 0.70 (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This demonstrates an excellent internal consistency of items addressing content knowledge which indicates that the items are reliable.

For items combined to address pedagogical knowledge (PK), item loadings for each item were found to be more than the minimum limit of 0.70 ($> .70$) and significant ($p < .001$) except for item 17 (Q17) with a loading of 0.67. However, since the Average Variance Extracted (AVE) was 0.61 above the minimum limit of 0.50 ($AVE > 0.50$), item 17 (Q17) was included. The AVE value of 0.61 shows that all the items come together to measure pedagogical knowledge. This indicates good convergent validity. For discriminant validity, the Heterotrait-Monotrait ratio (HTMT) values for PK and CK ($HTMT = .74$), PK and PCK ($HTMT = .68$), and PK and CtK ($HTMT = .63$) were within the acceptable threshold of $HTMT < .90$ (Henseler et al., 2015). This means each

of the PK, CK, PCK and CtK constructs assesses different issues. The Cronbach alpha value ($\alpha = .95$) and composite reliability ($CR = .96$) for PK were found above the minimum limit of 0.70 (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This indicates that items addressing pedagogical knowledge have an excellent internal consistency making them reliable.

For items combined to address pedagogical content knowledge (PCK), item loadings for each item were found to be higher than the minimum threshold of 0.70 (> 0.70) and significant ($p < .001$). The Average Variance Extracted (AVE) value for PCK was 0.72 above the acceptable limit of 0.50 ($AVE > 0.50$) (Bagozzi & Yi, 1988; Fornell & Larcker, 1981) which indicates a good convergent validity. This shows that all the items come together to address pedagogical content knowledge. For discriminant validity, the Heterotrait-Monotrait ratio (HTMT) values for PCK and CK ($HTMT = .56$), PCK and PK ($HTMT = .68$), and PCK and CtK ($HTMT = .74$) were found within the permissible limit of $HTMT < .90$ (Henseler et al., 2015). This implies that each of the PCK, CK, PK and CtK constructs deals with a separate issue. The Cronbach alpha value ($\alpha = .94$) and composite reliability ($CR = .95$) for PCK were found to be more than the minimum limit of 0.70. This demonstrates an excellent internal consistency for items addressing pedagogical content knowledge, making them reliable.

For items combined to address contextual knowledge (CtK), item loadings for each item were found significant ($p < .001$) and above the minimum threshold of 0.70. The Average Variance Extracted (AVE) value for CtK was 0.71, more than the threshold of 0.50 minimum ($AVE > 0.50$) (Bagozzi & Yi,

1988; Fornell & Larcker, 1981) which indicates good convergent validity. This means all the items come together to address contextual knowledge. For discriminant validity, the Heterotrait-Monotrait ratio (HTMT) values for CtK and CK (HTMT = .48), CtK and PK (HTMT = .63), and CtK and PCK (HTMT = .74) were found within the acceptable limit of $HTMT < .90$ (Henseler et al., 2015). This means each of the CtK, CK, PK and PCK constructs measures a different issue. The Cronbach alpha value ($\alpha = .94$) and composite reliability (CR = .95) for CtK were found above the 0.70 limits (Hair et al., 2016; Hair et al., 2010; Jain & Angural, 2017; Nunnally & Bernstein, 1994). This suggests that items addressing contextual knowledge have an excellent internal consistency making them reliable. Figure 11 provides a graphical presentation of item loadings, AVE and correlations for content, pedagogical, pedagogical content and contextual knowledge.

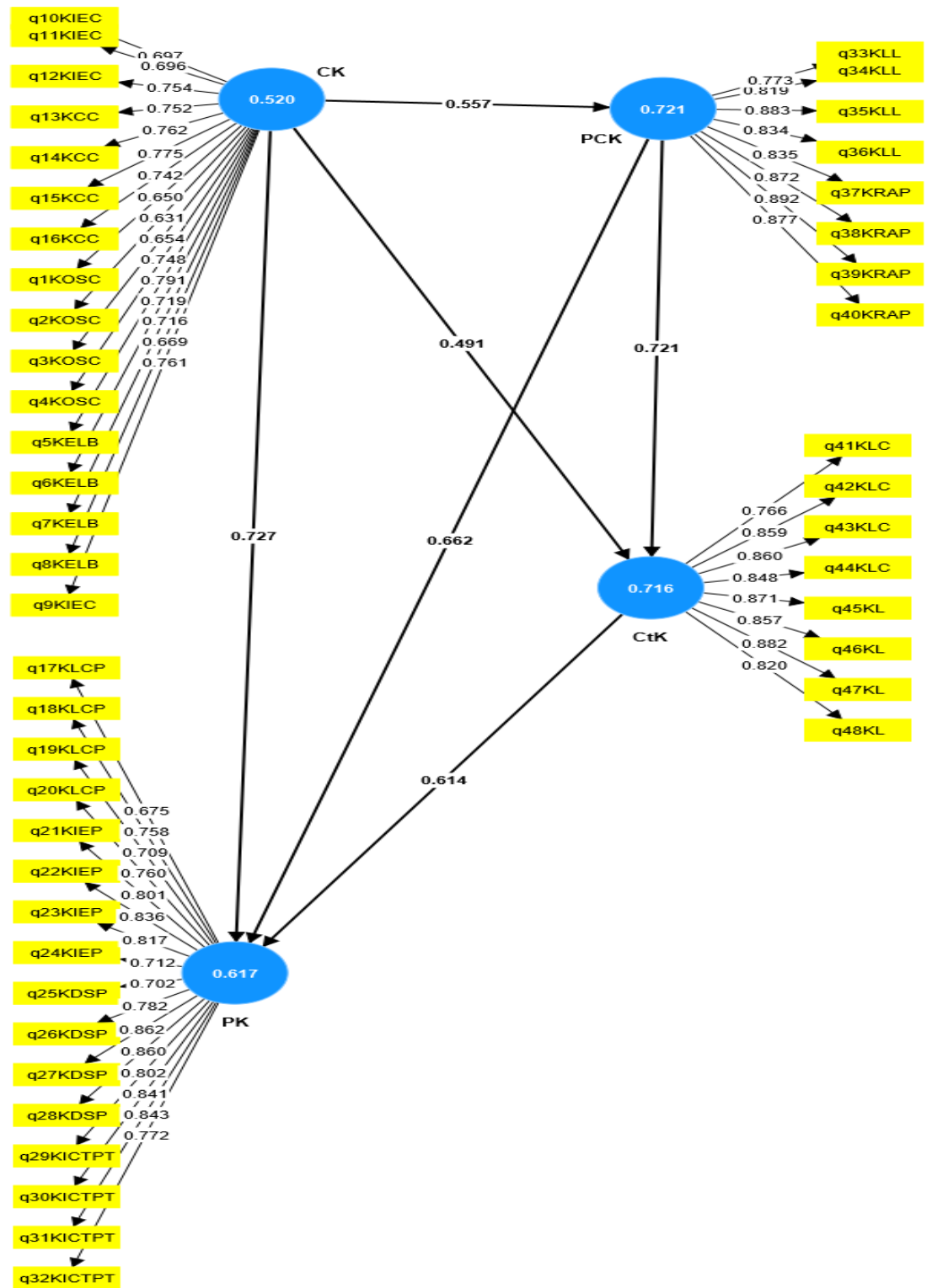


Figure 11: Item Loadings for Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK) and Contextual Knowledge (CtK)

Source: Fieldwork, 2023.

Regarding the SMPT face and content validity, Cohen's Kappa Coefficient (κ) shows the 2 raters' agreement level was excellent, [$\kappa = .89$, SE = .04, 95% CI, (0.81, 0.96), $p < .001$]. This agreement was significant. In line with Landis and Koch's (1977) criteria; Cohen's Kappa Coefficient (κ) less than ($<$) 0 was regarded as poor agreement; 0.0 to 0.20 was considered as slight agreement; 0.21 to 0.40 was regarded as fair agreement; 0.41 to 0.60 was seen as moderate agreement; 0.61 to 0.80 was considered as substantial agreement and $\kappa \geq 0.81$ was regarded as outstanding agreement. The result shows the raters' judgement for the SMPT face and content validity was very good. After pilot testing, the item difficulty of the SMPT for Basic 1 to Basic 6 was checked. Crocker and Algina's (1986) criteria were used to calculate the item difficulty index (p-value) by finding the students who correctly answered an item divided by the total students who answered that item and expressing it in terms of percentage. The results obtained are reported in Table 11.

Table 11: Item Difficulty Index (p-value) for the SMPT

Items	SMPT	SMPT	SMPT	SMPT	SMPT	SMPT
	B1	B2	B3	B4	B5	B6
	P-value	P-value	P-value	P-value	P-value	P-value
Q1	.63(63%)	.69(69%)	.63(63%)	.75(75%)	.63(63%)	.69(69%)
Q2	.63(63%)	.69(69%)	.63(63%)	.56(56%)	.63(63%)	.63(63%)
Q3	.63(63%)	.69(69%)	.63(63%)	.63(63%)	.63(63%)	.56(56%)
Q4	.63(63%)	.56(56%)	.63(63%)	.69(69%)	.63(63%)	.63(63%)
Q5	.63(63%)	.56(56%)	.63(63%)	.63(63%)	.63(63%)	.69(69%)
Q6	.63(63%)	.56(56%)	.69(69%)	.50(50%)	.63(63%)	.56(56%)
Q7	.69(69%)	.56(56%)	.69(69%)	.63(63%)	.63(63%)	.63(63%)
Q8	.69(69%)	.69(69%)	.63(63%)	.56(56%)	.75(75%)	.63(63%)
Q9	.63(63%)	.63(63%)	.56(56%)	.75(75%)	.75(75%)	.69(69%)
Q10	.63(63%)	.63(63%)	.63(63%)	.69(69%)	.63(63%)	.69(69%)
Q11	.56(56%)	.75(75%)	.69(69%)	.63(63%)	.63(63%)	.75(75%)

Table 11, Continued

Q12	.69(69%)	.75(75%)	.69(69%)	.69(69%)	.56(56%)	.63(63%)
Q13	.63(63%)	.69(69%)	.69(69%)	.69(69%)	.69(69%)	.63(63%)
Q14	.63(63%)	.69(69%)	.63(63%)	.63(63%)	.63(63%)	.69(69%)
Q15	.63(63%)	.63(63%)	.56(56%)	.63(63%)	.56(56%)	.75(75%)
Q16	.56(56%)	.69(69%)	.69(69%)	.63(63%)	.56(56%)	.69(69%)
Q17	.56(56%)	.75(75%)	.69(69%)	.63(63%)	.63(63%)	.75(75%)
Q18	.63(63%)	.75(75%)	.75(75%)	.69(69%)	.75(75%)	.63(63%)
Q19	.63(63%)	.69(69%)	.50(50%)	.63(63%)	.63(63%)	.69(69%)
Q20	.63(63%)	.69(69%)	.56(56%)	.69(69%)	.63(63%)	.69(69%)

Source: Fieldwork, 2023; p-value = item difficulty index

From Table 11, to interpret the item difficulty index (p-value) of the items, Hopkins and Antes's (1990) criteria were used. Items with a p-value $\geq .86$ were considered "very easy items" and were revised, p-values ranging from .71 to .85 were considered "easy items" and were modified, p-values ranging from .30 to .70 were considered "moderate items" and were retained, p-values ranging from .15 to .29 were described as "difficult items" and were modified, and p-values $\leq .14$ were classified as "very difficult items" and were discarded. The results for SMPT items for Basic 1 show that all the items from Q1 to Q20 had p-values ranging from .56 to .69, indicating moderately difficult items. Hence, all the items were retained with no revision. For SMPT items for Basic 2, except for Q11, Q12, Q17 and Q18 with p-values of .75 indicating easy items that were revised, the remaining items had p-values ranging from .56 to .69, signifying moderately difficult items were retained without revision.

For SMPT items for Basic 3, almost all the items had p-values ranging from .50 to .69, implying moderately difficult items and hence were retained without revising them, except for Q18 with a p-value of .75 which was considered an easy item and was revised. Regarding SMPT items for Basic 4,

the majority of the items had p-values ranging from .50 to .69 which indicates that the items had moderate difficulty. As a result, they were retained without modifying them except for Q1 and Q9 which had p-values of .75 and were regarded as easy items. Hence, Q1 and Q9 were revised. The majority of the SMPT items for Basic 5 had p-values ranging from .56 to .69, indicating moderately difficult items and were retained without modification. However, Q8 and Q9 items with p-values of .75 were considered easy items and were revised. Most of the SMPT items for Basic 6 had p-values ranging from .56 to .69, implying moderately difficult items and were maintained without revising them, except for Q11, Q15 and Q17 with p-values of .75 which were classified as easy items and were modified.

In addressing the reliability of the SMPT, the Spearman-Brown split-half reliability coefficient was estimated. Each SMPT for a particular class was split into odd-number items and even-number items and the split-half correlation and Spearman-Brown reliability coefficient were calculated. The results obtained are presented in Table 12.

Table 12: Spearman-Brown Split-Half Reliability Test of the SMPT

SMPT	Split-Half Correlation (r)	Spearman-Brown Coefficient (r_{SB})
Basic 1 SMPT	.947	.973
Basic 2 SMPT	.950	.975
Basic 3 SMPT	.660	.795
Basic 4 SMPT	.621	.766
Basic 5 SMPT	.906	.951
Basic 6 SMPT	.630	.773

Source: FieldWork, 2023; r = Split-Half Correlation; r_{SB} = Spearman-Brown Coefficient

The results in Table 12 show that, for Basic 1 SMPT, the split-half correlation ($r = .94$) between the odd-number items and even-number items was very strong. The Spearman-Brown coefficient ($r_{SB} = .97$) of equal length for Basic 1 SMPT was found above the minimum threshold of 0.70 (Sencan, 2005; Tezbasaran, 1997), indicating a very good internal consistency of the items addressing Basic 1 SMPT. For Basic 2 SMPT, a very strong split-half correlation ($r = .95$) was found with the corresponding Spearman-Brown coefficient ($r_{SB} = .97$) of equal length above the minimum limit of 0.70 (Sencan, 2005; Tezbasaran, 1997). This suggests that Basic 2 SMPT is reliable. A strong split-half correlation ($r = .66$) was found for Basic 3 SMPT with the associated Spearman-Brown coefficient ($r_{SB} = .79$) of equal length above the acceptable threshold of 0.70 (Sencan, 2005; Tezbasaran, 1997), indicating that the Basic 3 SMPT is reliable.

For Basic 4 SMPT, a strong split-half correlation ($r = .62$) was obtained with the corresponding Spearman-Brown coefficient ($r_{SB} = .76$) of equal length above the acceptable limit of 0.70 (Sencan, 2005; Tezbasaran, 1997), indicating that Basic 4 SMPT is reliable. For Basic 5 SMPT, a very strong split-half correlation ($r = .90$) was discovered and the associated Spearman-Brown coefficient ($r_{SB} = .95$) of equal length was higher than the required threshold of 0.70 (Sencan, 2005; Tezbasaran, 1997). This means that Basic 5 SMPT is reliable. Regarding Basic 6 SMPT, a strong split-half correlation ($r = .63$) was found and the corresponding Spearman-Brown coefficient ($r_{SB} = .77$) of equal length was above the permissible threshold of 0.70 (Sencan, 2005; Tezbasaran, 1997), indicating that Basic 6 SMPT is reliable.

Concerning the face and content validity of the TIG, Cohen's Kappa Coefficient (κ) of the 2 expert raters demonstrates a significant agreement, [$\kappa = .72$, $SE = .24$, 95% CI, (0.24, 1.19), $p = .04$]. Per Landis and Koch's (1977) criteria, the result suggests that the 2 raters' agreement for the TIG face and content validity was substantial.

Ensuring Trustworthiness of the Qualitative Data

As much as quantitative researchers are concerned with ensuring validity and reliability, qualitative researchers are also interested in ensuring the "trustworthiness" of qualitative data and the research process as a whole (Johnson, 1997). In this regard, addressing the issue of trustworthiness in this study, the researcher employed Lincoln and Guba's (1985) criteria for assessing trustworthiness which are frequently utilised in the literature. These are "credibility", "transferability", "dependability", and "confirmability".

In addressing "credibility", that is, ensuring that data was credible and trustworthy, the researcher employed "triangulation", "prolonged engagement", "member checking" and frequent "peer debriefing". Regarding "triangulation", the researcher initially employed a quantitative method utilising a questionnaire to collect data on teachers' knowledge about the standards-based mathematics curriculum and its implementation. Also, the study's hypotheses were tested. Certain unique quantitative results were obtained on teachers' knowledge about the standards-based mathematics curriculum, teachers' implementation of the curriculum, statistical differences in teachers' curriculum implementation across the grade levels they teach and statistical differences in teachers' knowledge about the standards-based mathematics curriculum across the grade

levels they teach. These were further probed qualitatively utilising a semi-structured interview guide.

On “prolonged engagement”, right from the beginning of the quantitative phase which lasted for 3 to 4 weeks, a friendly rapport and an excellent relationship with the study’s participants were established. This longer period of a good relationship with participants continued to the second phase before the researcher purposively (extreme or deviant case purposive sampling) selected some of them for the interview section which also lasted for almost 2 weeks.

On “member checking”, the researcher sent a request officially to every respondent who was engaged in the interview section to ask for assistance for each to cross-examine his/her interview transcript. This was to ensure each respondent authenticates his/her own responses and genuinely admits that such responses represent his/her own views, and also to point out inconsistencies he/she thinks do not represent his/her views in the interview transcript.

Regarding “peer debriefing”, the researcher engaged his colleague PhD candidates frequently through online presentations for them to examine step-by-step, the interview transcripts (de-identified) and also analyse how it was interpreted and reported. The researcher made sure that the interview transcripts were de-identified in order not to reveal the respondents’ identities as promised. Inputs and feedback offered were incorporated to enhance the trustworthiness of my data.

In addressing “transferability”, the researcher employed “thick description”. This was done to ensure that a reader relates the data and how it was interpreted and reported to his/her own experiences and context. Again, to

inform a reader to make appropriate judgements about the data. Initially, the researcher gave a detailed description of the method employed for collecting the interview responses from the respondents as well as the study site. The researcher further provided a detailed transcription of the interview responses. Additionally, the researcher provided a detailed step-by-step analysis of the interview transcripts. Results and findings were thoroughly discussed, interpreted and reported to enhance “transferability” as a way of increasing trustworthiness.

In dealing with “dependability”, that is, ensuring that others could take up a similar approach and arrive at a consistent result, once you address “credibility” sufficiently, you are primarily addressing how dependable your data is as well (Guba & Lincoln, 1989). In line, apart from employing “triangulation”, “prolonged engagement”, “member checking”, and frequent “peer debriefing” as earlier discussed in ensuring credible data, the researcher also employed “detailed description” and “involvement of my supervisors for auditing” to further strengthen “dependability”. The researcher provided a detailed description of the method employed for collecting the interview responses. The researcher further offered a detailed transcription of the interview transcripts, their analysis, interpretation and reporting. Regarding the “involvement of my supervisors for auditing”, the researcher gave the work to my supervisors for a thorough step-by-step scrutiny and cross-examination of all the steps and methods employed for collecting, analysing, interpreting and reporting the interview responses from the respondents as a way of making the data credible.

In attending to “confirmability”, that is, minimising biases and reporting data factually without infiltrating it with my own experiences and feelings, apart from employing “member checking”, “involvement of my supervisors for auditing” and “peer debriefing” as earlier discussed, the researcher further complemented these by utilising my “reflexive diary”, and also “linking findings to literature”. My “reflexive diary” is a step-by-step record concerning steps and methods as well as certain decisions and actions taken when collecting the interview responses from the respondents. In making sure that biases were minimised and reported factually, the researcher always referred to these records to keep track of actions and decisions previously taken. Also, to assess how they could not influence the way interview responses were analysed, presented and reported. Strengthening “confirmability”, the researcher linked the findings obtained from the interview responses to previous studies’ findings. This further provided a means of ensuring the trustworthiness of the data.

Data Collection Procedures

Before collecting the data, the researcher officially wrote a letter (see Appendix G) which was routed through my supervisor for his consent. The supervisor issued a letter of consent (see Appendix H) which was subsequently forwarded to the “Department of Business and Social Sciences Education (DoBSSE)” for an acceptance letter (see Appendix I) permitting the researcher to officially engage with the “University of Cape Coast Institutional Review Board (UCC-IRB)”. After fulfilling all the requirements, an ethical clearance letter with an ID Number of UCCIRB/CES/2023/121 (see Appendix J) was issued to start data collection. Again, before engaging the teachers in the field, the researcher wrote a letter (see Appendix K) to the Techiman Municipal

Education Directorate requesting an introductory letter to engage the teachers. The researcher was issued an introductory letter (See Appendix L) to that effect which aided engagement with the teachers. The researcher followed these protocols duly to adhere to ethical standards since gathering data from human respondents required it.

To start with, the researcher administered an Informed Consent Form to teachers (see Appendix M) and students (see Appendix N). Teachers and students were engaged within the school working hours from 8:00 am to 2:30 pm each day. With the teachers and students contacted, the researcher initially introduced himself and explained the purpose of his visit. The researcher explained to them the purpose of the study and the need for them to be involved. However, it was made clear to them that their involvement was not by force and even if they get involved, they may withdraw anytime they feel inconvenienced. The researcher explained the procedures for responding to each instrument and the possible time allocated. The researcher also made the teachers aware that upon their agreement, some would be later interviewed. It was explained to them that in case they agreed to take part in the study, the risk and discomfort they may encounter would be minimal and not detrimental. The researcher explained the possible benefits of the study to them and the public in general.

Again, the researcher made it known to them that any information they would provide would be kept confidential and their identities would not be revealed to anyone. It was further explained to them that there would not be any material benefit or payment of any kind for their involvement in the study. The researcher made his contacts available and assured them that when answering items on each instrument they may contact him anytime and share their

concerns. All the teachers and students engaged never showed any hesitation to participate in the study, and voluntarily signed or thumb-printed to indicate their agreement to participate in the study. The researcher also signed certifying that all it takes for a respondent to know to voluntarily agree to participate in the study had been catered for. After their acceptance and willingness to participate in the study, the researcher requested the contact of the teachers so that in the course of responding to the instruments, the researcher could communicate with them to know the progress and also to collect the instruments with ease. After this, the researcher started with the first phase by collecting quantitative data.

The researcher administered the TKS BMCQ personally to 942 teachers from basic 1 to basic 6 who were selected through the census sampling technique. This was done to collect data on teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum and its implementation. The researcher administered the hard copy of the TKS BMCQ to teachers in person. The researcher scheduled to meet the teachers during the first break from 10:00 am to 10:30 am and the second break from 12:30 pm to 1:00 pm each day. After giving the TKS BMCQ, the teachers were allowed some time to fill in the part which bordered on teachers' knowledge, and it was collected on the same day. However, in the part of the TKS BMCQ which bordered on teachers' implementation practices, the researcher allowed himself a one-week interval before contacting them. The researcher called and visited the teachers for it. Table 13 presents the return rate of 942 TKS BMCQ administered to the teachers which focused on teachers' knowledge and implementation of the curriculum.

Table 13: Return Rate of the TKSBMCQ

TKSBMCQ	Number of items	Percentage (%)	Decision
Received but incomplete	42	4.45	discarded
Received but not filled at all	29	3.10	discarded
Not received at all	68	7.21	discarded
Received and fully completed	803	85.24	Retained and used for analysis
Total TKSBMCQ	942	100.00	

Source: Fieldwork, 2023

From Table 13, out of 942 TKSBMCQ administered, items that the researcher received but were incomplete summed up to 42, representing 4.45%. Such items were removed and not used for the analysis. Twenty-nine (29) items constituted those that the researcher received but were not filled at all, representing 3.10% and such items were also discarded and not included in the analysis. Items the researcher did not receive at all were 68, representing 7.21%. Equally, such items were not considered for the analysis. 803 items were received fully completed, representing 85.24% and such items were retained and used for the analysis. Fincham (2008) maintains that to cover a wide area, a return rate of $\geq 80\%$ should be the focus of the researcher. Hence, obtaining an 85.24% return rate was within an acceptable range of $\geq 80\%$. This suggests that the majority of the basic primary school teachers were involved in the study.

The researcher visited the schools and administered the SMPT personally to students from basic 1 to basic 6 to collect data on their mathematics academic performance. Each time a teacher was sampled from basic 1 to basic 6 in a particular school in a circuit as indicated in Table 5 (see p. 142), 70% (more than half of the students in a class) of students in the class

taught by that particular teacher were chosen through a simple random procedure by employing RNG software and the SMPT was given to such students. The average performance of such students from the SMPT was calculated to represent students' performance in the class and paired with such teacher's knowledge about the standards-based mathematics curriculum. This was done to ensure that students taught by a particular teacher were paired with such a teacher to ascertain the influence of such a teacher's knowledge about the standards-based mathematics curriculum on their students' performance.

The researcher engaged the students during the first break from 10:00 am to 10:30 am and the second break from 12:30 pm to 1:00 pm each day. Each time the researcher visited a school, with the help of the teachers, the researcher gave the SMPT to students and allowed them time to take it on the same day. Since it requires students to use 15 to 20 minutes, it made it possible for the researcher to collect the SMPT on the same day the researcher visited a school. The researcher was able to gather all the 942 average performance scores of students from the SMPT in the various schools from basic 1 to basic 6. However, the average performance scores of students from the SMPT whose teachers' TKSBMCQ items were received but incomplete (42 items), received but not filled at all (29 items) and not received at all (68 items) as shown in Table 13 (see p. 182) were removed from the average performance scores of the SMPT and not included in the analysis. This was because such students' average performance scores from the SMPT could not be paired with their teachers' knowledge scores from the TKSBMCQ due to the fact that either their teachers' TKSBMCQ items were received but incomplete, received but not filled at all or not received at all. Hence, removing 139 ($42 + 29 + 68$) average performance

scores of students from the 942 average performance scores of students. The remaining average performance scores were 803, representing an 85.24% return rate.

The researcher started the second phase after the first phase by collecting qualitative data employing the TIG. Thirty-three (33) teachers were selected purposively employing “extreme or deviant case sampling” for an interview. Initially, the researcher scheduled a time with the selected teachers. The researcher explained to them that, in the first phase when data were collected from them and analysed certain unique results were found on teachers’ low implementation of ICT which was extreme compared to other implementations of the curriculum. The researcher also explained to them that a statistically significant difference in teachers’ knowledge of the standards-based mathematics curriculum was found across teachers in Basic 1, 2, 3, 4, 5 and 6.

Again, the researcher made them aware that a statistically significant difference in teachers’ implementation of the standards-based mathematics curriculum was found across teachers in Basic 1, 2, 3, 4, 5 and 6. Once more, the researcher explained to them that the results obtained seem to suggest that teachers in Basic 1, 2, 4 and 3 appear to demonstrate moderately higher knowledge of the standards-based mathematics curriculum as compared to teachers in Basic 5 and 6. Likewise, it was explained to them that the results seem to suggest that teachers in Basic 1, 2, 4 and 3 appear to demonstrate moderately higher implementation of the standards-based mathematics curriculum as compared to teachers in Basic 5 and 6.

As a result, it was explained to them the need to interview them on their perspectives regarding what could account for these unique results to have a

comprehensive understanding. The researcher discussed with them a convenient time for the interview and made them aware that a voice recorder would be used to record the interview conversation. Further, the researcher assured them that any information they would provide shall be protected, kept secret and confidential and their identities not revealed to anyone. They agreed to have the interview with the researcher during the first break from 10:00 am to 10:30 am and the second break from 12:30 pm to 1:00 pm each day in their various classrooms.

The researcher planned the visit in such a way that each school was reached before the end of the first break which started from 10:00 am to 10:30 am and the second break from 12:30 pm to 1:00 pm. The researcher employed a face-to-face interview approach to interview each teacher selected. Before starting each interview section, the researcher created a welcoming atmosphere for each to express himself/herself freely. Adding to this, the researcher initially established a good relationship and rapport with them right from the beginning of the first phase, so during the interview section, they saw the researcher as a friend. This created a friendly conversation and made them open up more frankly.

As previously discussed with them and with their consent, a voice recorder was placed in front of the researcher during the interview section. It was visible to each teacher during the interview conversation, which recorded each interview section with a teacher. After interviewing each teacher, the researcher played back each interview conversation for a teacher to admit his/her own responses before leaving the school. The researcher further informed each teacher that a transcript of his/her responses regarding the

interview conversation would be sent back to him/her for confirmation. Each interview section with a teacher lasted for 30 to 35 minutes.

In all, 21 teachers were interviewed due to saturation. To further ensure that no new responses emerged, 3 more teachers were interviewed to find out their responses. The responses given were not different from the earlier ones. To further strengthen this, another 3 more teachers were interviewed. Similarly, their responses did not produce any new responses. Therefore, out of the 33 teachers to be interviewed, 21 teachers' interviews were taken into account due to the saturation of the data, which represented 63.63%. In line with many scholars' views (Grady, 1998 cited in Guest, Bunce, & Johnson, 2006; Saunders et al., 2018), when conducting an interview and it reaches saturation, there is no point in collecting further data. Hence, 21 teachers' interviews were used for the analysis.

Ethical Considerations

Wiles, Crow, Heath and Charles (2008) assert that privacy, anonymity and confidentiality are paramount concerns for conducting research. In line, the researcher adhered to and observed all these right away from the pilot testing of instruments, and data collection through to data processing and analysis as well as presenting and reporting the findings. The researcher initially obtained ethical clearance with an ID number UCCIRB/CES/2023/121 from the "University of Cape Coast Institutional Review Board (UCC-IRB)" (see Appendix J). This officially permitted the researcher to start with pilot testing of the instruments and consequently, data collection.

Before pilot testing the instruments and collecting data, the researcher sought the consent of the teachers and students by administering an Informed

Consent Form to the teachers (see Appendix M) and students (see Appendix N) involved. The researcher visited the teachers and students officially and introduced himself and explaining the purpose and benefits of the study to them. The researcher explained the procedures for responding to each instrument and the time they may require to complete. The researcher also explained to the teachers their subsequent involvement in the study. The teachers and students were made aware that the possible risks and discomfort they may encounter by involving themselves in the study were minimal and not detrimental. Throughout this discussion with the teachers and students, it was made known to them that participating in the study was not compulsory. They were further informed that even if they were involved in the study and at a certain point they were inconvenienced, they may withdraw. The teachers and students willingly agreed and volunteered to participate in the study.

The researcher again assured them of keeping their identities anonymous regarding any data they may provide. In doing this, pseudonyms and IDs instead of the teachers' and students' actual names were used. This was done to keep the respondents' identities hidden and not to disclose them. The researcher promised to protect their privacy. In ensuring this, the words and expressions used in presenting and reporting the data and its findings were not linked to personally identifying information about the teachers and students. This ensured that their information was kept secret and not traced to reveal their identities.

Furthermore, the teachers and students were assured of the researcher's strongest attachment to the confidentiality and safety of their data. To ensure this, the researcher used an encrypted electronic file with a password to store

the data provided. It was ensured that no person had access to the data provided. In processing and analysing the data, the researcher coded the data with no links to personally identifying information about the teachers and students. Similarly, results and findings were presented and reported with no references to any of the teachers' or students' personally identifying information. The researcher stored the data for the duration of the work and deleted it safely after the work.

Data Processing and Analysis

Analyses of data were done quantitatively and qualitatively using the data obtained from the Teachers' Knowledge about the Standards-based Mathematics Curriculum Questionnaire (TKSBMCQ), Students' Mathematics Performance Test (SMPT), and Teachers' Interview Guide (TIG). The units of analysis were teachers and students from Basic 1 to Basic 6. Initially, data obtained from the TKSBMCQ, SMPT, and TIG were manually reviewed to check for errors, omissions and inconsistencies to improve the quality and accuracy of the data collected. Also, coded data were checked in terms of duplication and completeness in order not to have missing values which could affect the quality of the data analysis.

Quantitative Data Analysis

The analysis of quantitative data constitutes inferential and descriptive statistics. Descriptive statistics include finding means, standard deviations, skewness and kurtosis of respondents' scores, while inferential statistics deal with using statistical tools such as One-Way MANCOVA, One-Way ANCOVA and Hierarchical Multiple Linear Regression to test the formulated hypotheses. SPSS versions 22 and 27 and SmartPLS 4 software were employed for

inferential and descriptive statistical analyses. The SPSS data file was saved as a CSV file and imported into SmartPLS 4.

For data coding into SPSS, responses of items on the TKSBMCQ were assigned the following codes. For teachers' demographic information, gender options were coded as 1= male and 0 = female, years of experience in teaching and age in years data were collected as continuous data. Hence, no codes were assigned to them. For teachers' academic qualifications: 1= Certificate 'A', 2= Diploma, 3= 1st Degree, 4= Master's Degree, and 5= PhD. For the mode of certificate acquisition: 1= Distance, 2= Sandwich, 3= Regular, and 4= Part-time. For grade level: 1= Basic 1, 2 = Basic 2, 3 = Basic 3, 4 = Basic 4, 5 = Basic 5, and 6 = Basic 6. These codes do not represent a numerical value or any weight but were assigned to various categories for labelling purposes.

However, for each item that looked at teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum, the code assigned to the response of each item, 1= 'true', 0= 'false/not sure', represented a numerical value or weight. The "true" option indicated the correct response with a score of 1. Both "false" and "not sure" options were regarded as incorrect responses and were awarded a score of 0. Similarly, for each item that looked at teachers' implementation, the code assigned to the response of each item, 0= never, 1= almost never, 2= occasionally, 3 = almost every time, and 4 = every time, represented a numerical value or weight. "Never" attracted a score of 0, "almost never" had a score of 1, "occasionally" with a score of 2, "almost every time" had a score of 3, and "every time" with a score of 4.

For items on the SMPT, students' age was collected as continuous data. Hence, no codes were assigned to them. In each class, the students' average age was calculated for the selected students and used to represent the students' age in the class. For each item that assessed students' mathematics performance, the code assigned to the response of each item, 1= 'true', 0= 'false/not sure', represented a numerical value or weight. The "true" option indicated the correct response with a score of 1. Both "false" and "not sure" options were regarded as incorrect responses and were awarded a score of 0. Data collected on teachers' and students' demographic information were analysed using descriptive statistics by finding frequencies and percentages.

To address research questions 1, 2, 3 and 4 on teachers' content, pedagogical, pedagogical content and contextual knowledge respectively about the standards-based mathematics curriculum, data from the TKSBMCQ were analysed employing descriptive statistics by finding mean, standard deviations, skewness and kurtosis of respondents' scores. Also, research question 5 on teachers' implementation of the curriculum was addressed by utilising data obtained from the TKSBMCQ. Mean, standard deviations, skewness and kurtosis of respondents' scores were used for analysing and discussing the data.

To address research questions 1 and 2 on content knowledge (CK) and pedagogical knowledge (PK), quantitative data were collected by assessing teachers' knowledge on a dichotomous scale where a "true response" was scored 1, indicating knowledge while a "false" or "not sure" response was scored 0 indicating a lack of knowledge. Zaidi et al. (2021) criteria for assessing knowledge, which considered $\leq 30\%$ of a maximum score as poor knowledge, 31%-59% of a maximum score as moderate knowledge and $\geq 60\%$ of a

maximum score as good knowledge, were adjusted and used to assess the teachers' knowledge. This was done to have a comprehensive understanding of teachers' knowledge.

Therefore, based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the maximum mean score was regarded as low knowledge, 34% - 66.9% of the maximum mean score was considered as moderate knowledge and $\geq 67\%$ of the maximum mean score was seen as high knowledge. Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was considered as low knowledge, 0.34-0.66 was regarded as moderate knowledge and 0.67-1.00 was seen as high knowledge. However, assessing the overall knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was considered as low knowledge, 1.36-2.69 was seen as moderate knowledge and 2.70-4.00 signified high knowledge. Again, assessing the overall knowledge of each content and pedagogical knowledge by putting together the 4 sub-dimensions addressing each using 16 items, a mean score of 0.00-5.43 was regarded as low knowledge, 5.44-10.71 implied moderate knowledge and 10.72-16.00 was considered as high knowledge of content knowledge and pedagogical knowledge about the standards-based mathematics curriculum.

To address research questions 3 and 4 on pedagogical content knowledge (PCK) and contextual knowledge (CtK), based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the maximum mean score was considered as low knowledge, 34% -66.9% of the maximum mean score was

regarded as moderate knowledge and $\geq 67\%$ of the maximum mean score was seen as high knowledge. Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was regarded as low knowledge, 0.34-0.66 implied moderate knowledge and 0.67-1.00 was considered as high knowledge. However, assessing the overall knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was seen as low knowledge, 1.36-2.69 implied moderate knowledge and 2.70-4.00 was regarded as high knowledge. Again, assessing the overall knowledge of each pedagogical content and contextual knowledge by putting together the 2 sub-dimensions addressing each using 8 items, a mean score of 0.00-2.71 was considered as low knowledge, 2.72-5.35 was regarded as moderate knowledge, and 5.36-8.00 implied high knowledge of pedagogical content and contextual knowledge about the standards-based mathematics curriculum.

To address research question 5 on the extent of the implementation of the standards-based mathematics curriculum, data from the TKS BMCQ were analysed employing descriptive statistics by finding mean, standard deviations, skewness and kurtosis of the respondents' scores. Nine (9) sub-dimensions were examined. These included implementing the curriculum's organisation and structure, expected learning behaviours, instructional expectations, core competencies, learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, ICT implementation and recommended assessment practices implementation. On a 5-point Likert scale (0=never, 1=almost never, 2=occasionally, 3=almost every time, 4=every time), teachers' implementation of the standards-based mathematics curriculum was assessed to gather quantitative data. "Never" attracted a score of 0, "almost

never” had a score of 1, “occasionally” with a score of 2, “almost every time” had a score of 3, and “every time” with a score of 4. Rosecrans et al.’s (2008) criteria for assessing implementation, which considered $\leq 49\%$ of a maximum score as low implementation, 50%-74% of a maximum score as moderate implementation, and $\geq 75\%$ of a maximum score as high implementation, were adjusted to assess teachers’ implementation. The adjustment was to make it possible to include end-points and also to have a comprehensive understanding of the results.

Therefore, based on a 5-point Likert scale (0=never, 1=almost never, 2=occasionally, 3=almost every time, 4=every time) and using the Rosecrans et al. (2008) adjusted criteria for assessing implementation, $\leq 49.9\%$ of the maximum mean score was regarded as low implementation; 50% -74.9% of the maximum mean score was considered as moderate implementation and $\geq 75\%$ of the maximum mean score was seen as high implementation. Hence, for each item addressing a particular sub-dimension implementation, a mean score of 0.00-1.99 was regarded as low implementation, 2.00-2.99 implied moderate implementation and 3.00-4.00 was considered as high implementation. However, assessing the overall implementation of the sub-dimension of the curriculum's organisation and structure using 2 items, a mean score of 0.00-3.99 was considered as low implementation, 4.00-5.99 was regarded as moderate implementation and 6.00-8.00 implied high implementation.

Apart from this, assessing the overall implementation of each remaining sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-7.99 was considered as low implementation, 8.00-11.99 implied moderate implementation and 12.00-16.00 was regarded as high implementation. Again,

assessing the overall implementation of the curriculum by putting together the 9 sub-dimensions addressing the implementation using 34 items, a mean score of 0.00-67.99 was considered as low implementation, 68.00-101.99 was regarded as moderate implementation, and 102.00-136.00 implied high implementation of the standards-based mathematics curriculum.

To test the first hypothesis (H_{01}), a One-Way MANCOVA was employed to test if there was a significant difference in teachers' content, pedagogical, pedagogical content, and contextual knowledge scores about the standards-based mathematics curriculum across their academic qualification, mode of certificate acquisition and grade levels controlling for the effects of their years of experience in teaching, age and gender. Separate analyses of One-Way MANCOVA were done for each independent variable to examine statistical differences if any in teachers' content, pedagogical, pedagogical content and contextual knowledge scores when their years of experience in teaching, age and gender were controlled for. MANCOVA analysis requires two or more continuous dependent variables, one or more categorical independent variables, and one or more covariates. Teachers' knowledge scores (content, pedagogical, pedagogical content and contextual) constituted continuous dependent variables, academic qualification, mode of certificate acquisition and grade levels formed categorical independent variables, and teachers' years of experience in teaching, age and gender were considered as covariates. MANCOVA was considered appropriate as it helps to control the effects of covariates on other variables (Hersherberger, 2005). Therefore, to ensure that teachers' knowledge was not influenced by their years of teaching experience, age and gender, MANCOVA was adopted to control these variables.

To test the second hypothesis (H_{02}), a One-Way ANCOVA was employed to test if there was a significant difference in teachers' standards-based mathematics curriculum implementation across their grade levels, controlling for the effects of their years of experience in teaching, age, and gender. ANCOVA analysis requires one continuous dependent variable, one or more categorical independent variables, and one or more covariates. Teachers' implementation scores constituted a continuous dependent variable, grade levels formed a categorical independent variable, and teachers' years of experience in teaching, age and gender were regarded as covariates. ANCOVA was considered appropriate as it allows you to control for the effects of a confounding variable (covariate) on your result (Manea, Hristian, Ostafe, Apostol & Sandu, 2016; Wu & Cook, 2015). Therefore, to ensure that teachers' implementation was not influenced by their years of teaching experience, age and gender, ANCOVA was adopted to control these variables.

To test the third hypothesis (H_{03}), a Hierarchical Multiple Linear Regression was employed to test whether there were any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about standards-based mathematics curriculum on their implementation, controlling for the effects of their years of experience in teaching, age, and gender. Hierarchical Multiple Linear Regression analysis requires one continuous dependent variable, two or more continuous independent variables and one or more covariates. Teachers' implementation scores constituted a continuous dependent variable, teachers' knowledge scores (content, pedagogical, pedagogical content and contextual) formed continuous independent variables and teachers' years of experience in teaching, age, and

gender were regarded as covariates. Hierarchical Multiple Linear Regression was considered appropriate as it helps to determine the influence of predictors on a variable, controlling for the effects of other variables (covariates) (Lewis, 2007). Therefore, to test the influence of teachers' knowledge on their curriculum implementation, controlling for the effects of their years of teaching experience, age and gender, a Hierarchical Multiple Linear Regression was deemed appropriate.

Similarly, to test the fourth hypothesis (H_{04}), a Hierarchical Multiple Linear Regression was employed to test whether there were any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content, and contextual knowledge) about standards-based mathematics curriculum on students' academic performance controlling for the effects of their years of experience in teaching, age, gender and students' average age. Students' average academic performance scores constituted a continuous dependent variable, teachers' knowledge scores (content, pedagogical, pedagogical content and contextual) formed continuous independent variables and years of experience in teaching, age, gender and students' average age were regarded as covariates.

Qualitative Data Analysis

The researcher employed thematic analysis for analysing and interrogating data obtained from the Teachers' Interview Guide (TIG). Braun and Clarke's (2006) standpoint of thematic analysis was employed which highlights the need to "familiarise yourself with the data, identify codes, form themes, review the themes, define and rename the themes and write your narrative". The researcher collected the interview responses personally. As a

result, became familiar with the interview responses. In order to strengthen this, initially, the researcher played and listened to the audio recordings of the interview several times to make them more familiar. This complemented my understanding of the interview responses. Afterwards, the researcher transcribed verbatim the recorded responses of the teachers' interviews using "Google Docs". To ensure accurate transcription, the researcher further went through the interview transcripts thoroughly. Subsequently, the researcher played and listened to the recordings of the original interview audio and double checked and compared them with the interview transcripts generated from "Google Docs". Corrections were made to reflect the respondents' actual responses.

The researcher coded the responses from the interview transcripts manually employing inductive coding. Codes were primarily developed as the researcher read through the transcripts line by line. With the help of the "Microsoft Word comment feature", the researcher highlighted each sentence, right-clicked and moved to the new comment section, and assigned code to each sentence read using respondents' precise words. In some instances, the meaning was made from a sentence, and such understanding was used to assign a code for such sentences without necessarily using respondents' precise words. With the assistance of the "Microsoft Word comment feature" and the "DocTools feature" each code and its "excerpt" were easily organised in a table.

Pseudonyms (Teacher 1, Teacher 2, Teacher 3, Teacher 4, Teacher 5, etc.) were assigned to "excerpts" of responses to keep respondents' identities anonymous. The researcher carefully analysed codes and "excerpts" generated using the "Microsoft Word comment feature" and the "DocTools feature".

Thereafter, similar codes were grouped into one theme. “Excerpts” of codes grouped into one theme were also brought under each theme. The researcher went over and improved the initial themes formed by reviewing and refining them. Some of the initial themes were grouped into one theme and appropriate names were assigned.

For teachers’ responses on what could account for the low ICT implementation concerning the standards-based mathematics curriculum, 67 codes were generated. These codes were further grouped into 5 themes comprising inadequate ICT resources and tools, lack of administrative support, inadequate training and workshops on ICT, inadequate knowledge of ICT integration, and inadequate trained ICT teachers to handle ICT. Regarding what could account for teachers’ moderately higher knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3, and 4 and what could account for the moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6, 40 codes were generated and grouped into 3 themes for the interviews done in Basic 1, 2, 3 and 4 while 45 codes were generated and grouped into 3 themes for the interviews done in Basic 5 and 6. The themes generated for Basic 1, 2, 3, and 4 were training on differentiated learning (DL) and professional learning community (PLC), teachers’ input, commitment and passion, teachers’ knowledge, experience and expertise. The themes for Basic 5 and 6 consisted of the nature of the curriculum, inadequate training and workshops, and teachers’ knowledge, attitudes, expertise and experience.

For teachers’ responses on what could account for the moderately higher implementation of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4 and what could account for the moderately lower implementation of the

standards-based mathematics curriculum in Basic 5 and 6, 39 codes were generated and grouped into 5 themes for the interviews done in Basic 1, 2, 3 and 4 while 43 codes were generated and grouped into 3 themes for the interviews done in Basic 5 and 6. The themes generated for Basic 1, 2, 3 and 4 were high monitoring and supervision, teachers' style and mode of implementation, training, support and available resources, teachers' commitment and input, and teachers' knowledge and experience. The themes for Basic 5 and 6 consisted of inadequate resources for the implementation, inadequate training and workshops and the nature of the curriculum.

In line with Payne, Muenks and Aguayo's (2021) view, employing thematic analysis is appropriate as it helps to provide detailed interpretations of themes supported by data. Similarly, it helps to compare and link data (Alhojailan & Ibrahim, 2012). Therefore, to thoroughly interrogate, analyse, compare and link teachers' responses to the quantitative findings, thematic analysis was considered the most useful tool. Table 14 presents the summary of the quantitative and qualitative data analyses employed.

Table 14: Summary of the Data Analysis

Research Questions and Hypotheses	Kind of Analysis	Tools Employed
Research Questions 1, 2, 3, 4 and 5	Quantitative (Descriptive Statistics)	Mean, standard deviation, skewness and kurtosis
Hypothesis 1	Quantitative (Inferential Statistics)	One-Way MANCOVA
Hypothesis 2	Quantitative (Inferential Statistics)	One-Way ANCOVA
Hypothesis 3	Quantitative (Inferential Statistics)	Hierarchical multiple linear regression
Hypothesis 4	Quantitative (Inferential Statistics)	Hierarchical multiple linear regression
Interview Responses/Transcript	Qualitative	Thematic Analysis

Source: Fieldwork, 2023

Chapter Summary

The Chapter describes the methods employed in assessing the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. The study employed a mixed-method approach, specifically a sequential explanatory design with a follow-up explanation model variant. A total of 942 teachers from public primary basic 1 to basic 6 were selected through simple random and purposive sampling techniques. 70% (more than half of the students in a class) of students in a class (basic 1 to basic 6) taught by a particular teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students from the SMPT was calculated to represent students' performance in the class and paired with such teacher's knowledge about the standards-based mathematics curriculum. A questionnaire, interview guide, and test were employed for data collection. Both quantitative (descriptive and inferential statistics) and qualitative (thematic analysis) analyses were employed for analysing the data gathered.

On limitations, the study could not cover a broad range of factors such as availability of resources, teachers' beliefs, attitudes, motivation and value for the new curriculum which could affect teachers' curriculum implementation. Additionally, the study could not employ observation to watch teachers' activities in the classroom. The study concentrated only on teachers' knowledge and its influence on curriculum implementation and students' performance even though teachers' years of experience in teaching, age and gender were controlled. Again, the study could not cover teachers and students in kindergarten and junior high schools. Moreover, private schools were not considered at all. Only public primary teachers and students were involved in the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The study examined the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. A sequential explanatory design with a follow-up explanation model variant was employed. The study was done in two phases. Phase 1 dealt with collecting quantitative data on teachers' knowledge and implementation of the standards-based mathematics curriculum using TKSBMCQ. Also, data on students' average performance scores were collected in Phase 1 using SMPT. Phase 2 involved a follow-up data collection to explain certain unique quantitative findings that were obtained in Phase 1 using TIG.

Regarding this Chapter, the presentation of results and their discussions were based on the return rate of the TKSBMCQ administered to the teachers ($n = 803$; 85.24%), students' average performance scores from the SMPT ($n = 803$; 85.24%), and subsequent follow-up interviews. Twenty-one (21) teachers' interviews were taken into account due to the saturation of the data. Respondents' demographic information was analysed using frequencies and percentages. Research questions 1, 2, 3, 4 and 5 were analysed quantitatively using mean, standard deviations, skewness and kurtosis.

Hypotheses 1 and 2 were tested inferentially using One-Way MANCOVA and One-Way ANCOVA respectively, while hypotheses 3 and 4 were tested using Hierarchical multiple linear regression. Tables and Figures were used to present the results. The qualitative data were presented and discussed thematically alongside the respective research question and

hypothesis that showed unique and interesting results. In terms of the presentation of results and their discussions, respondents' demographic characteristics were presented and discussed first, followed by the research questions (1, 2, 3, 4 and 5) and the hypotheses (1, 2, 3 and 4). The last aspect of the Chapter provided a summary of the key findings of the study.

Demographic Characteristics of the Teachers

As part of understanding the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance, the demographic information of the teachers was sought. The information sought included their gender, years of experience in teaching, age in years, academic qualifications, mode of certificate acquisition, and the grade level they teach. This information was further used in testing the hypotheses. The results obtained are presented in Table 15 using frequencies and percentages.

Table 15: Demographic Characteristics of the Teachers

Variable	Subscale	Teachers (N= 803)	
		Freq.	%
Gender	Male	365	45.5
	Female	438	54.5
Teaching Experience	1-10 years	447	55.7
	11-20 years	282	35.1
	21-30 years	53	6.6
	31 years and above	21	2.6
Age (in years)	20-30 years	144	17.9
	31-40 years	490	61.0
	41-50 years	110	13.7
	51 years and above	59	7.3
Academic qualification	Certificate 'A'	11	1.4
	Diploma	336	41.8
	1 st Degree	443	55.2
	Master's Degree	13	1.6
	PhD	0	0.0

Table 15, Continued

Mode of Certificate Acquisition	Distance	351	43.7
	Sandwich	183	22.8
	Regular	269	33.5
	Part-Time	0	0.0
Grade Level	Basic 1	137	17.1
	Basic 2	126	15.7
	Basic 3	138	17.2
	Basic 4	136	16.9
	Basic 5	132	16.4
	Basic 6	134	16.7

Source: Fieldwork, 2023

From Table 15, the results show that more female teachers ($n = 438$; 54.5%) participated in the study than male teachers ($n = 365$; 45.5%). Regarding years of teaching experience of the teachers, the majority of the teachers (447; 55.7%) had 1 to 10 years of teaching experience in the classroom. Those who had 11 to 20 years of classroom teaching experience were 282 teachers, representing 35.1%. 53 teachers representing 6.6% had 21 to 30 years of experience in teaching. Those who had 31 years and above experience in teaching were 21 teachers, representing 2.6%. A downward trend was observed, as the years of experience in teaching increased, the number of teachers decreased. For instance, fewer teachers were found to have taught for 31 years and above as compared to most of the teachers with 1 to 10 years of experience in teaching.

Concerning the teachers' ages, most of them were between 31 to 40 years ($n = 490$; 61.0%), followed by 20 to 30 years ($n = 144$; 17.9%). Those between 41 to 50 years were 110 teachers representing 13.7%. Only a few teachers ($n = 59$; 7.3%) were 51 years and above. The teachers' mean age was 37 years. It was observed that the majority of the teachers were in their youthful ages between 20 to 40 years which accounted for 78.9% of the teachers.

On teachers' academic qualifications, the majority of the teachers ($n = 443$; 55.2%) were 1st degree holders, followed by Diploma holders ($n = 336$; 41.8%). Those with a master's degree ($n = 13$; 1.6%) were slightly more than those with Certificate 'A' ($n = 11$; 1.4%). None of the teachers possessed a PhD. In terms of the mode of acquiring a certificate, the majority of the teachers ($n = 351$; 43.7%) acquired their certificate through the distance mode, followed by the regular mode ($n = 269$; 33.5%), and next were those who had their certificate through the Sandwich mode ($n = 183$; 22.8%). None of the teachers acquired their certificate through the Part-time mode.

Regarding the grade level the teachers teach, most of the teachers who participated in the study were in Basic 3 ($n = 138$; 17.2%) and Basic 1 ($n = 137$; 17.1%), followed by Basic 4 ($n = 136$; 16.9%) and Basic 6 ($n = 134$; 16.7%). Basic 5 ($n = 132$; 16.4%) and Basic 2 ($n = 126$; 15.7%) had the fewest number of teachers who participated in the study.

Demographic Characteristics of the Students

The students' demographic information was also sought as part of assessing the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. The demographic information was sought on students' age. The selected students' average age was calculated and used to represent students in a class. Students' demographics (such as sex and whether students receive extra tuition from home) whose average could not be calculated were excluded. This was because 70% (more than half of the students in a class) of students in a class taught by a teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students was calculated to represent students'

performance in a class and paired with a teacher's knowledge about the standards-based mathematics curriculum.

Therefore, representing a class with “an average sex and an average of whether students receive extra tuition from home” was impossible since an average of these demographics could not be estimated to represent a class, hence their exclusion from the demographics. The data for students' average age was recoded into categories using SPSS despite being collected as continuous data in order to analyse the distribution of the average ages. The data on students' average age distribution in the various classes from basic 1 to basic 6 are presented in Table 16 using frequencies and percentages. Also, hypothesis 4 was tested using students' average ages as a covariate.

Table 16: Demographic Characteristics of Students' Average Age Distribution

Class	Number of Average Ages	Average Age Distribution	Freq.	%
Basic 1	137	6-8 years	121	88.3
		9-11 years	16	11.7
		12 years and above	0	0.0
Basic 2	126	6-8 years	62	49.2
		9-11 years	64	50.8
		12 years and above	0	0.0
Basic 3	138	6-8 years	14	10.1
		9-11 years	110	79.7
		12 years and above	14	10.1
Basic 4	136	6-8 years	6	4.4
		9-11 years	105	77.2
		12 years and above	25	18.4
Basic 5	132	6-8 years	0	0.0
		9-11 years	57	43.2
		12 years and above	75	56.8
Basic 6	134	6-8 years	0	0.0
		9-11 years	8	6.0
		12 years and above	126	94.0

Source: Fieldwork, 2023

From Table 16, the results reveal that for students' average ages in Basic 1, most of the students' average age was found between 6 to 8 years old ($n = 121$; 88.3%), followed by 9 to 11 years old ($n = 16$; 11.7%). None of the students' average ages were 12 years and above ($n = 0$; 0.0%). Regarding students' average ages in Basic 2, the majority of the students' average age was between 9 to 11 years old ($n = 64$; 50.8%), followed by 6 to 8 years old ($n = 62$; 49.2%). None of the students' average ages were 12 years and above ($n = 0$; 0.0%). It was observed that in Basic 1 and Basic 2, students' average ages were not 12 years and above. The students' average ages in Basic 1 and Basic 2 suggest that the students were below 12 years old.

Regarding students' average ages in Basic 3, the vast majority of the students' average age was between 9 to 11 years old ($n = 110$; 79.7%), between 6 to 8 years old ($n = 14$; 10.1%) and 12 years and above ($n = 14$; 10.1%) were found to be equal. Concerning students' average ages in Basic 4, the majority of the students' average age was between 9 to 11 years old ($n = 105$; 77.2%), followed by 12 years and above ($n = 25$; 18.4%) and the least students' average age was found between 6 to 8 years ($n = 6$; 4.4%). For students' average ages in Basic 5, the vast majority of the students' average age was 12 years and above ($n = 75$; 56.8%), followed by 9 to 11 years old ($n = 57$; 43.2%). None of the students' average ages were between 6 to 8 years ($n = 0$; 0.0%). Regarding students' average ages in Basic 6, the vast majority of the students' average age was 12 years and above ($n = 126$; 94.0%), followed by 9 to 11 years ($n = 8$; 6.0%). None of the students' average ages were between 6 to 8 years ($n = 0$; 0.0%).

It was observed that in Basic 5 and Basic 6, students' average ages were not found between 6 to 8 years and the majority of the students' average ages were 12 years and above. The results of the average age distribution of the students further revealed that as their grade level increased, the average age increased.

Results and Discussion of the Main Research Questions and Hypotheses

This section displays the results and discussion of the research questions and hypotheses formulated to guide the study. It covers 5 research questions and 4 hypotheses. The result of each research question was first presented, and then its discussion followed. After presenting and discussing the results of the research questions, each hypothesis's result was presented and discussed.

Research Question 1: What is the content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?

This research question sought to examine teachers' content knowledge about the standards-based mathematics curriculum. By content knowledge, the researcher meant these four sub-dimensions: teachers' knowledge about the organisation and structure of the curriculum (KOSC), knowledge about expected learning behaviour (learning domains) (KELB), knowledge of instructional expectations about the curriculum (KIEC), and knowledge of the core competencies (KCC). Quantitative data were collected by assessing teachers' knowledge on a dichotomous scale where a "true response" was scored 1 indicating knowledge while a "false" or "not sure" response was scored 0 indicating a lack of knowledge. The analysis and discussion of the quantitative data were done using mean, standard deviations, skewness and kurtosis of

respondents' scores. Based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the maximum mean score was regarded as low knowledge, $34\% - 66.9\%$ of the maximum mean score was considered as moderate knowledge and $\geq 67\%$ of the maximum mean score was viewed as high knowledge.

Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was regarded as low knowledge, 0.34-0.66 implied moderate knowledge and 0.67-1.00 was considered as high knowledge. However, assessing the overall knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was viewed as low knowledge, 1.36-2.69 was considered as moderate knowledge and 2.70-4.00 signified high knowledge. Again, assessing the overall content knowledge (CK) by putting together the 4 sub-dimensions addressing CK using 16 items, a mean score of 0.00-5.43 was regarded as low knowledge, 5.44-10.71 was considered as moderate knowledge, and 10.72-16.00 was viewed as high knowledge of CK of the standards-based mathematics curriculum. The results obtained for KOSC, KELB, KIEC and KCC are presented in Tables 17, 18, 19 and 20 respectively.

Table 17: Teachers' Knowledge about Organisation and Structure of the Curriculum (KOSC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. The new curriculum is organised into strands, sub-strands, content standards and learning indicators.	803	.57	.496	-.275	.086	-1.929	.172

Table 17, Continued

2. An indicator is an outcome that the learner must exhibit each year to meet the content standard expectation.	803	.62	.486	-.485	.086	-1.769	.172
3. The annotation, B1. 1. 2. 1. 1 indicates class 1, strand 1, sub-strand 2, content standard 1, and learning indicator 1.	803	.62	.485	-.507	.086	-1.747	.172
4. The major strands of the mathematics curriculum are numbers, algebra, geometry and measurement, and data.	803	.63	.482	-.557	.086	-1.694	.172
Overall knowledge of KOSC	803	2.44	.961	-.169	.086	-.436	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 17, the results show that for the items addressing teachers' knowledge about the organisation and structure of the curriculum (KOSC), teachers' knowledge of the major strands of the mathematics curriculum ($M = .63$; $SD = .48$) was moderately higher than their knowledge of the annotations ($M = .62$; $SD = .48$), the meaning of an indicator ($M = .62$; $SD = .48$), and organisation of the curriculum into strands, sub-strands, content standards and learning indicators ($M = .57$; $SD = .49$). Overall, regarding the knowledge of KOSC, teachers demonstrated moderate knowledge ($M = 2.44$; $SD = .96$). An inspection of the skewness and kurtosis values shows that the data is normally distributed since the skewness statistics lie within ± 2 and kurtosis statistics

within ± 7 (Kline, 2016). Table 18 presents the results of teachers' knowledge of expected learning behaviour.

Table 18: Teachers' Knowledge of Expected Learning Behaviour (KELB)

Item	N	M	SD	Skewness Statistic	Std. Error	Kurtosis Statistic	Std. Error
1. The expected learning behaviours (learning domains) of the mathematics curriculum constitute knowledge, understanding and application, process skills, attitudes and values.	803	.62	.485	-.502	.086	-1.753	.172
2. In the highest level of the learning domains of the mathematics curriculum, the learner is expected to analyse, synthesise, evaluate and create.	803	.61	.489	-.437	.086	-1.814	.172
3. It is envisaged that teaching and learning of the new mathematics curriculum should be consistent with the development of skills such as observing, classifying, comparing, communicating, reporting, predicting, and interpreting.	803	.63	.483	-.540	.086	-1.713	.172
4. It is envisaged that by teaching and learning the new mathematics curriculum, learners develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness.	803	.60	.490	-.410	.086	-1.836	.172
Overall Knowledge of KELB	803	2.46	.998	-.262	.086	-.347	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 18 show that for each item addressing teachers' knowledge of expected learning behaviour (KELB), teachers demonstrated moderately ($M = .63$; $SD = .48$) higher knowledge of developing skills such as observing, classifying, comparing, reporting, predicting, and interpreting than their appreciation of the knowledge, understanding, application, process skills, attitudes and values ($M = .62$; $SD = .48$) which constituted the main domains of the KELB. Further, teachers' knowledge about developing commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness in learners as part of the KELB for teaching the new standards-based mathematics curriculum was moderately lower ($M = .60$; $SD = .49$) than their knowledge about the expectation for learners to analyse, synthesise, evaluate and create ($M = .61$; $SD = .48$) which constituted the highest level of the domains of learning. Overall, teachers showed a moderate level of knowledge about KELB ($M = 2.46$; $SD = .99$). Inspecting the skewness and kurtosis values reveals that the data is normally distributed because both statistics fall within a range of ± 2 and ± 7 respectively (Kline, 2016). Table 19 displays the results of teachers' knowledge of instructional expectations about the curriculum.

Table 19: Teachers' Knowledge of Instructional Expectations about the Curriculum (KIEC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. The focus of the new mathematics curriculum is moving the teaching and learning from the didactic acquisition of knowledge to deep learning.	803	.63	.483	-.540	.086	-1.713	.172
2. The new mathematics curriculum emphasises that learners be exposed to situations, tasks and activities that challenge them to construct their own knowledge and understanding.	803	.64	.480	-.596	.086	-1.649	.172
3. In teaching and learning the new mathematics curriculum, you are to engage learners to work together as colleagues and generate discourse among themselves.	803	.64	.480	-.596	.086	-1.649	.172
4. When teaching the new mathematics curriculum, teachers should act as a guide and facilitators.	803	.65	.477	-.636	.086	-1.599	.172
Overall Knowledge of KIEC	803	2.56	.944	-.233	.086	-.395	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 19, the results show that for each item addressing teachers' knowledge of instructional expectations about the curriculum (KIEC), teachers demonstrated moderately ($M = .65$; $SD = .47$) higher knowledge of acting as a

guide and facilitators as part of teaching the standards-based mathematics curriculum than their knowledge of exposing learners to situations, tasks and activities that challenge learners to construct their own knowledge and understanding ($M = .64$; $SD = .48$) and knowledge of engaging learners to work together as colleagues ($M = .64$; $SD = .48$). Teachers slightly demonstrated a moderately lower ($M = .63$; $SD = .48$) knowledge about the expectation of the curriculum that require them moving teaching and learning from the didactic acquisition of knowledge to deep learning. Overall, teachers' knowledge of KIEC was regarded as being moderate ($M = 2.56$; $SD = .94$). The data is normally distributed, as evidenced by an examination of the skewness and kurtosis values, which both fall within a range of ± 2 and ± 7 respectively (Kline, 2016). Table 20 shows the results of teachers' knowledge of the core competencies.

Table 20: Teachers' Knowledge of the Core Competencies (KCC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. The new mathematics curriculum emphasises that learners deepen their learning by developing critical thinking skills to solve real-life problems.	803	.62	.485	-.502	.086	-1.753	.172
2. The new mathematics curriculum emphasises that learners create new ideas as well as innovate in solving problems.	803	.60	.490	-.421	.086	-1.828	.172

Table 20, Continued

3. In the new curriculum, learners are to be actively engaged in collaborating and sharing their ideas in lessons.	803	.58	.494	-.311	.086	-1.908	.172
4. In the new mathematics curriculum, learners are to be engaged in self-awareness and building their self-esteem.	803	.62	.486	-.491	.086	-1.764	.172
Overall Knowledge of KCC	803	2.42	1.045	-.213	.086	-.535	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 20 show that for each item addressing teachers' knowledge of core competencies (KCC), teachers exhibited moderately higher knowledge of engaging learners in developing critical thinking skills to solve real-life problems ($M = .62$; $SD = .48$) and knowledge of engaging learners in self-awareness and self-esteem building ($M = .62$; $SD = .48$) as an aspect of developing the core competencies of the curriculum. Teachers' knowledge about engaging learners actively to collaborate and share their ideas in lessons as part of developing KCC was moderately lower ($M = .58$; $SD = .49$) than their knowledge about engaging learners to create new ideas as well as innovate in solving problems ($M = .60$; $SD = .49$). Overall, teachers demonstrated a moderate level of knowledge about KCC ($M = 2.42$; $SD = 1.04$). As evidenced by the skewness and kurtosis values, which both fall within a range of ± 2 and ± 7 respectively (Kline, 2016), the data is normally distributed. Further comparison of teachers' knowledge of KOSC, KELB, KIEC and KCC addressing content knowledge was done. The results are presented in Table 21.

Table 21: Comparison of Teachers' Knowledge of KOSC, KELB, KIEC and KCC

Sub-dimension	N	M	SD	Statistic	Skewness	Statistic	Kurtosis
					Std. Error		Std. Error
KOSC Scores	803	2.44	.961	-.169	.086	-.435	.172
KELB Scores	803	2.46	.998	-.262	.086	-.347	.172
KIEC Scores	803	2.56	.944	-.233	.086	-.395	.172
KCC Scores	803	2.42	1.045	-.213	.086	-.535	.172
Overall Knowledge of CK	803	9.89	2.393	.012	.086	-.030	.172

Source: Fieldwork, 2023; For each sub-dimension, a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge. For overall knowledge of CK, a mean score of 0.00-5.43 = low knowledge; 5.44-10.71 = moderate knowledge; 10.72-16.00 = high knowledge

From Table 21, by comparing teachers' knowledge of the 4 sub-dimensions addressing content knowledge (CK), the results reveal that teachers exhibited moderately higher knowledge of KIEC ($M = 2.56$; $SD = .94$) than their knowledge of KELB ($M = 2.46$; $SD = .99$) and KOSC ($M = 2.44$; $SD = .96$). The results further reveal that teachers demonstrated moderately lower knowledge of KCC ($M = 2.42$; $SD = 1.04$) as compared to the other sub-dimensions addressing CK. Overall, teachers' content knowledge (CK) in terms of KOSC, KELB, KIEC and KCC was found to be moderate ($M = 9.89$; $SD = 2.39$). Examining the skewness and kurtosis values, which both lie within a range of ± 2 and ± 7 respectively demonstrates that the data is normally distributed (Kline, 2016).

Discussion of Results of Research Question 1

Overall, the results of research question 1 revealed that the teachers' content knowledge regarding the standards-based mathematics curriculum in terms of their knowledge about the organisation and structure of the curriculum (KOSC), knowledge about expected learning behaviour (learning domains) (KELB), knowledge of instructional expectations about the curriculum (KIEC),

and knowledge of the core competencies (KCC) was moderate. This appears to suggest that the teachers' knowledge was average. As maintained by Shulman (1986, 1987), teachers' knowledge of content in terms of understanding structures and the organising principles is key. It thus suggests that teachers need to have an appreciable level of knowledge about the organisation and structure of the standards-based mathematics curriculum. For this reason, Rogan and Grayson (2003) also argue that when teachers possess limited knowledge of content, it could influence their curriculum implementation. This implies that teachers require a significant amount of content knowledge to effectively implement the curriculum. Relating Rogan and Grayson's (2003) concept of "capacity to innovate" in terms of teachers' knowledge to this study's findings, on average, it implies that the teachers are demonstrating an appreciable level of content knowledge about the implementation of the standards-based mathematics curriculum.

Regarding teachers' knowledge about expected learning behaviour (learning domains) (KELB), the teachers demonstrated moderate knowledge. This indicates that the teachers have an appreciable level of knowledge regarding the curriculum's required learning behaviours (learning domains). This finding is in line with the revelations made by Bitok (2020) and Katam and Jepchirchir (2018) who discovered that while most teachers were not fully acquainted with the learning domains, they demonstrated knowledge of the learning domains. Further, the current study's findings also show teachers exhibited moderately higher knowledge of developing skills such as observing, classifying, comparing, reporting, predicting, and interpreting which constitute

an integral part of the process skills development of the standards-based mathematics curriculum.

However, a revelation that appears interesting is the teachers' demonstration of moderately lower knowledge of developing commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness as part of the standards-based mathematics curriculum' required learning behaviours for learners. What this suggests is that the teachers may not consider developing commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness as the curriculum's learning behaviours that learners are to demonstrate. According to NaCCA (2019), the Ghanaian learner needs to be prepared to cultivate positive attitudes, values, and psycho-social abilities to be a competent and reflective citizen and solve personal and societal problems. This implies that teachers who are implementers of the standards-based mathematics curriculum need to demonstrate a high knowledge of these to infuse them in their teaching.

Concerning teachers' knowledge of instructional expectations about the curriculum (KIEC), the teachers showed a moderate level of knowledge. This suggests that the teachers are knowledgeable about the necessary instructional expectations that are part of the curriculum. Consistent with this finding, Pagana, Nyikahadzoyi, Mutambara and Chagwiza (2015) reported teachers' knowledge of the expectations for teaching mathematics curriculum. This current study's findings further show that the teachers exhibited moderately higher knowledge of acting as a guide and facilitators as part of delivering the standards-based mathematics curriculum. What this indicates is that the teachers

moderately understand their role of facilitating and guiding learners in teaching and learning mathematics. Consistent with this, NaCCA (2019) maintains that teachers need to understand their function as facilitators to encourage discourse among students. It was also discovered that the teachers' knowledge of exposing learners to situations, tasks and activities that challenge learners to construct their own knowledge and understanding and engaging learners to work together as colleagues was moderate. What this implies is that the teachers showed a certain level of understanding that they are expected to engage learners to work together as colleagues and also engage them in tasks that challenge them to discover knowledge for themselves.

In contrast to this current study's finding, the teachers showed moderately lower knowledge of the curriculum's goal of shifting teaching and learning from "didactic acquisition" of knowledge to deep learning. What this suggests is that the teachers have minimal knowledge of the curriculum expectation of moving teaching and learning from giving information to learners, rather than giving opportunities to learners through active involvement in their own knowledge construction. This finding also appears to suggest that the teachers still do not fully see the focus of the standards-based mathematics curriculum towards a constructivist approach to teaching and learning. Adentunde (2007) points out that when teachers adopt a non-constructivist approach to teaching and learning, they usually present lessons through an explanation which is usually a one-sided form of communication coming from the teacher. So, when teachers show minimal knowledge of the curriculum's goal of moving teaching and learning towards deep learning rather than a

“didactic acquisition” of knowledge, they may adopt teaching approaches that deviate from constructivist teaching approaches.

Regarding teachers’ knowledge of the core competencies (KCC), the teachers demonstrated a moderate level of knowledge. For instance, the teachers exhibited moderately higher knowledge of developing learners’ critical thinking skills in solving real-life problems which consequently deepens learners’ learning. This suggests that teachers demonstrated an appreciable level of knowledge about engaging learners to deepen their learning through critical thinking which is one of the key components of the core competencies of the standards-based mathematics curriculum. Thus, teachers’ knowledge in this regard is average. However, this is not consistent with the findings of Schulz and Fitzpatrick (2016), whose study revealed that teachers demonstrated inadequate knowledge of critical thinking skills. Similarly, these studies (Bakir, 2015; Sendag, Osman, Sezgin, & Dulkadir, 2015) findings revealed teachers’ lack of knowledge of critical thinking skills.

Also, regarding this current study’s findings, the teachers showed a moderately higher knowledge of engaging learners in self-awareness and self-esteem building as part of the core competencies development of the standards-based mathematics curriculum. What this suggests is that teachers appreciate that, regarding the standards-based mathematics curriculum delivery, learners are to be engaged in knowing themselves and self-esteem. NaCCA (2019) maintains that as a way of delivering the standards-based curriculum, learners are to be engaged by helping them identify and develop their talents and aspirations through self-awareness and self-esteem skills.

Further, the teachers exhibited a moderate knowledge of engaging learners in creativity, innovation and problem-solving as part of developing the core competencies of the curriculum. This suggests that the teachers showed some acceptable level of knowledge regarding creativity, innovation and problem-solving as components of the core competencies of the standards-based mathematics curriculum. The findings show consistency with Asoma, Ali, Adzifome and Appiah-Kubi (2022), whose study revealed teachers' moderate knowledge of problem-solving. However, in terms of the teachers' knowledge of creativity, this current study's finding contradicts Hana and Hacène's (2017) study, which found teachers' lack of understanding of creative thinking skills. In contrast to this current study's findings, Mahama (2022) reported that in-service teachers demonstrated a low level of nurturing behaviours in creativity.

It was discovered that the teachers demonstrate moderately lower knowledge of engaging learners to actively collaborate and share their ideas in lessons as part of developing communication and collaboration competencies skills. What this suggests is the teachers appear to assume the teacher-centred approach of delivering knowledge and concepts where learners are regarded as passive recipients of information already prepared. In such a situation, teachers direct teaching and learning based on what they want learners to learn (Jonassen & Jonassen, 2004).

Comparing the sub-dimensions addressing teachers' content knowledge regarding the standards-based mathematics curriculum, it was found that teachers demonstrated a moderately higher knowledge of instructional expectations about the curriculum (KIEC) compared to their knowledge of

expected learning behaviour (KELB), knowledge of organisation and structure of the curriculum (KOSC), and knowledge of the core competencies (KCC). What this implies is that the teachers appear to have more knowledge of what they are supposed to deliver regarding the standards-based mathematics curriculum. The findings further revealed the teachers' moderately low knowledge of the KCC. This appears to suggest that the teachers have little knowledge of the core competencies of the standards-based mathematics curriculum.

Research Question 2: What is the pedagogical knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?

This research question sought to examine teachers' pedagogical knowledge about the standards-based mathematics curriculum. By pedagogical knowledge, the researcher meant these four sub-dimensions: teachers' knowledge of learner-centred pedagogy (KLCP), knowledge of inclusion and equity pedagogy (KIEP), knowledge of differentiation and scaffolding pedagogy (KDSP), and knowledge of ICT as a pedagogical tool (KICTPT). On a dichotomous scale (1=true response; 0=false/not sure), teachers' knowledge was assessed to gather quantitative data. A "true response" received a score of 1, indicating knowledge, while a "false" or "not sure" response received a score of 0, indicating a lack of knowledge. Mean, standard deviations, skewness and kurtosis of respondents' scores were used in the analysis and discussion of the quantitative data.

Based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the

maximum mean score was considered as low knowledge, 34% -66.9% of the maximum mean score was regarded as moderate knowledge and $\geq 67\%$ of the maximum mean score was viewed as high knowledge. Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was seen as low knowledge, 0.34-0.66 implied moderate knowledge and 0.67-1.00 was regarded as high knowledge. However, assessing the overall knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was considered as low knowledge, 1.36-2.69 was regarded as moderate knowledge and 2.70-4.00 was viewed as high knowledge. Again, assessing the overall pedagogical knowledge (PK) by putting together the 4 sub-dimensions addressing PK using 16 items, a mean score of 0.00-5.43 was regarded as low knowledge, 5.44-10.71 was considered as moderate knowledge, and 10.72-16.00 implied high knowledge of PK of the standards-based mathematics curriculum. The results obtained for KLCP, KIEP, KDSP and KICTPT are reported in Tables 22, 23, 24 and 25 respectively.

Table 22: Teachers' Knowledge of Learner-Centred Pedagogy (KLCP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. In using learner-centred pedagogies, the learner is at the centre of the learning process, offered essential learning experiences and engaged in meaningful hands-on activities.	803	.64	.481	-.574	.086	-1.675	.172

Table 22, Continued

2. Learner-centred classroom entails engaging learners in problem-solving activities, inquiry-based activities, investigative activities, project-based work, creative-based work, think-pair-share activities, group work and discussion, cooperative and collaborative activities, case studies, and reflective discussions.	803	.64	.480	-.591	.086	-1.655	.172
3. In using learner-centred pedagogy, learners become actively engaged in discussing ideas and looking for answers through the inspiration of the facilitator.	803	.63	.484	-.524	.086	-1.730	.172
4. Learner-centred pedagogy aims to make learners take ownership of their learning and become constructors of knowledge.	803	.63	.482	-.551	.086	-1.700	.172
Overall Knowledge of KLCP	803	2.54	.987	-.219	.089	-.551	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 22 show that for each item addressing teachers' knowledge of learner-centred pedagogy (KLCP), teachers demonstrated moderately higher knowledge of placing the learner at the centre of the learning process ($M = .64$; $SD = .48$) and engaging them in activities such as problem-solving, inquiry-based, and project-based work. ($M = .64$; $SD = .48$). Teachers' knowledge about engaging learners actively in discussing ideas and looking for their own answers ($M = .63$; $SD = .48$) and making learners take ownership of their learning ($M = .63$; $SD = .48$) was moderately lower. Overall, regarding teachers' knowledge of learner-centred pedagogy (KLCP), teachers

demonstrated a moderate knowledge ($M = 2.54$; $SD = .98$). Data is normally distributed since skewness and kurtosis values lie within a range of ± 2 and ± 7 respectively (Kline, 2016). Table 23 presents the results of teachers' knowledge of inclusion and equity pedagogy.

Table 23: Teachers' Knowledge of Inclusion and Equity Pedagogy (KIEP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Inclusion and equity pedagogy entails ensuring that daily learning activities are quality and accessible to all learners.	803	.62	.487	-.474	.086	-1.779	.172
2. Inclusion and equity of the new mathematics curriculum entail using a variety of approaches that address learners' background, diversity and special needs in the learning process.	803	.65	.478	-.619	.086	-1.621	.172
3. Inclusion and equity of the new curriculum entail recognising individual learners' needs, learning experiences, and levels of motivation in planning and delivering a lesson.	803	.66	.476	-.654	.086	-1.577	.172
4. Effective use of inclusion and equity in the classroom entails making instruction meaningful by aligning instruction to the learner's interests, abilities, and potential.	803	.63	.482	-.557	.086	-1.694	.172
Overall Knowledge of KIEP	803	2.56	.975	-.121	.086	-.640	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 23, the results show that for each item addressing teachers' knowledge of inclusion and equity pedagogy (KIEP), teachers demonstrated moderately higher knowledge of recognising individual learner's needs,

learning experiences and levels of motivation ($M = .66$; $SD = .47$), followed by using a variety of approaches that address learners' background, diversity and special needs ($M = .65$; $SD = .47$). Teachers' knowledge with regard to ensuring that daily learning activities are quality and accessible to all learners was moderately lower ($M = .62$; $SD = .48$) than their knowledge about making instruction meaningful by aligning to the learner's interests, abilities and potential ($M = .63$; $SD = .48$). Overall, regarding teachers' knowledge of inclusion and equity pedagogy (KIEP), the teachers exhibited a moderate knowledge ($M = 2.56$; $SD = .97$). As evidenced by the Skewness and kurtosis values which lie within the range of ± 2 and ± 7 respectively (Kline, 2016), the data is normally distributed. Table 24 displays the results of teachers' knowledge of differentiation and scaffolding pedagogy.

Table 24: Teachers' Knowledge of Differentiation and Scaffolding Pedagogy (KDSP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Differentiation entails accommodating differences in learners' learning styles, interests and readiness, and setting different tasks for learners of different abilities so that each learner in a group has the best possible chance of learning.	803	.62	.485	-.502	.086	-1.753	.172
2. Differentiation is by content, process, product, tasks, learning activities, affect, learning environment and assessment.	803	.63	.484	-.529	.086	-1.724	.172

Table 24, Continued

3. In scaffolding, we use a variety of instructional techniques to assist/support learners move progressively towards a stronger understanding and ultimately greater independence in the learning process.	803	.63	.484	-.518	.086	-1.736	.172
4. Scaffolding entails providing learners with lesson vocabulary, exemplars, and models to increase their understanding.	803	.60	.490	-.421	.086	-1.828	.172
Overall Knowledge of KDSP	803	2.48	1.051	-.252	.086	-.480	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 24, the results show that for each item addressing teachers' knowledge of differentiation and scaffolding pedagogy (KDSP), teachers exhibited moderately higher knowledge of differentiation as encompassing content, process, product, tasks, affect, learning environment and assessment ($M = .63$; $SD = .48$) and knowledge of scaffolding learners' learning by using a variety of instructional techniques ($M = .63$; $SD = .48$). Teachers' knowledge about providing lessons vocabulary, exemplars and models was moderately lower ($M = .60$; $SD = .49$) than their knowledge about accommodating differences in learners' learning styles, interests, readiness and setting different tasks ($M = .62$; $SD = .48$) as part of KDSP. Overall, teachers exhibited moderate knowledge ($M = 2.48$; $SD = 1.05$) regarding their knowledge of differentiation and scaffolding pedagogy (KDSP). The data is normally distributed, as indicated by the skewness and kurtosis values, which both values fall within a

range of ± 2 and ± 7 , respectively (Kline, 2016). Table 25 illustrates the results of teachers' knowledge of ICT as a pedagogical tool.

Table 25: Teachers' Knowledge of ICT as a Pedagogical Tool (KICTPT)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Under the new mathematics curriculum, integration of ICT is considered a key tool to enhance deep and independent learning.	803	.60	.491	-.394	.086	-1.849	.172
2. Multimedia such as text, audio, graphics, animation, and videos are useful tools to enhance learners' learning.	803	.61	.487	-.469	.086	-1.785	.172
3. Using ICT tools in lesson delivery is a way of providing learners access to large quantities of information.	803	.63	.483	-.540	.086	-1.713	.172
4. Exposing learners to ICT in the teaching and learning process is a way of increasing their level of motivation, level of competence and ability to apply ICT in later years within and outside of mathematics.	803	.63	.484	-.524	.086	-1.730	.172
Overall Knowledge of KICTPT	803	2.47	.999	-.300	.086	-.342	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 25 regarding teachers' knowledge of ICT as a pedagogical tool (KICTPT) show that teachers demonstrated moderately higher knowledge of using ICT as a way of providing learners access to large quantities

of information ($M = .63$; $SD = .48$) and increasing their level of motivation, competence and ability to apply ICT ($M = .63$; $SD = .48$). Teachers' knowledge about the integration of ICT as a key tool under the standards-based mathematics curriculum to enhance deep and independent learning ($M = .60$; $SD = .49$) was moderately lower than their knowledge about usefulness of multimedia to enhance learners' learning ($M = .61$; $SD = .48$). Overall, concerning teachers' knowledge of ICT as a pedagogical tool (KICTPT), teachers showed a moderate knowledge ($M = 2.47$; $SD = .99$). The skewness and kurtosis values, which both fall within ranges of ± 2 and ± 7 , respectively, show that the data is normally distributed (Kline, 2016). Further, a comparison of teachers' knowledge of KLCP, KIEP, KDSP and KICTPT addressing pedagogical knowledge was done. The results are displayed in Table 26.

Table 26: Comparison of Teachers' Knowledge of KLCP, KIEP, KDSP and KICTPT

Sub-dimension	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
KLCP Scores	803	2.54	.987	-.219	.086	-.551	.172
KIEP Scores	803	2.56	.975	-.121	.086	-.640	.172
KDSP Scores	803	2.48	1.051	-.252	.086	-.480	.172
KICTPT Scores	803	2.47	.999	-.300	.086	-.342	.172
Overall	803	10.03	2.444	-.135	.086	-.039	.172
Knowledge of PK							

Source: Fieldwork, 2023; For each sub-dimension, a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge. For overall knowledge of PK, a mean score of 0.00-5.43 = low knowledge; 5.44-10.71 = moderate knowledge; 10.72-16.00 = high knowledge

From Table 26, comparing teachers' knowledge of the 4 sub-dimensions addressing pedagogical knowledge (PK), the results show that teachers

exhibited moderately higher knowledge of KIEP ($M = 2.56$; $SD = .97$) than their knowledge of KLCP ($M = 2.54$; $SD = .98$) and KDSP ($M = 2.48$; $SD = 1.05$). The results further reveal that teachers demonstrated moderately lower knowledge of KICTPT ($M = 2.47$; $SD = .99$) as compared to the other sub-dimensions addressing PK. Overall, teachers' pedagogical knowledge (PK) in terms of KLCP, KIEP, KDSP and KICTPT was found to be moderate ($M = 10.03$; $SD = 2.44$). The data is normally distributed, as shown by an examination of the skewness and kurtosis values, which both fall within ranges of ± 2 and ± 7 , respectively (Kline, 2016).

Discussion of Results of Research Question 2

The overall results of research question 2 show that the teachers demonstrated a moderate level of pedagogical knowledge of the standards-based mathematics curriculum in terms of their knowledge of learner-centred pedagogy (KLCP), knowledge of inclusion and equity pedagogy (KIEP), knowledge of differentiation and scaffolding pedagogy (KDSP), and knowledge of ICT as a pedagogical tool (KICTPT). This result seems to imply that the teachers have average knowledge of the recommended pedagogies of the curriculum. As emphasised by Shulman (1987), teachers need knowledge of instructional activities which include the pedagogies used in the classroom to complement content and pedagogical content knowledge.

Due to the necessity of teachers' pedagogical knowledge, Shulman (1987) re-echoed the need to reinforce pedagogical reasoning and action in classroom activities. Rogan and Grayson (2003) argue that when teachers possess limited knowledge, it could influence their curriculum implementation. This suggests that teachers need sufficient knowledge of pedagogies in order to

enhance the implementation of the standards-based mathematics curriculum. Relating Rogan and Grayson's (2003) idea of "capacity to innovate" in terms of teachers' knowledge to this study's findings, on average, it could be inferred that the teachers are demonstrating an appreciable level of pedagogical knowledge about the implementation of the standards-based mathematics curriculum.

Regarding teachers' knowledge of learner-centred pedagogy (KLCP), teachers demonstrated a moderate level of knowledge. This suggests the teachers exhibited an acceptable level of knowledge about learner-centred pedagogy. This finding is consistent with that of Chibunn, Unamba, and Olawuyi (2017), who reported mathematics teachers' knowledge of learner-centred pedagogy in their study. Similarly, consistent with this finding, Chipphiko and Shawa (2014) reported teachers' knowledge of learner-centred pedagogy. Madani and Forawi's (2019) study also agrees with this finding, which reported teachers' knowledge of major aspects of the new curriculum for mathematics and science in terms of student-centred pedagogies. This indicates that the findings agree with the aforementioned studies that most teachers appear to demonstrate an appreciable level of knowledge regarding learner-centred pedagogy.

The teachers also exhibited moderately higher knowledge of placing learners at the centre of the learning process, and engaging them in meaningful activities such as problem-solving, inquiry-based, project-based work, creative-based work, group work and discussion. As indicated by Black (2007), learner-centred pedagogy requires giving autonomy to learners, where learners have control over their learning. What this suggests is that teachers allow learners to

explore and construct their own knowledge and understanding. Even though the teachers exhibited moderately higher knowledge of putting learners at the centre of the teaching process, their knowledge of engaging learners to take ownership of their learning to construct their knowledge and understanding was moderately lower. What this suggests is that the teachers appear to see themselves as dispenser of information to learners.

Concerning teachers' knowledge of inclusion and equity pedagogy (KIEP), the teachers demonstrated moderate knowledge. What this indicates is that the teachers showed some appreciable level of knowledge about inclusion and equity pedagogy. This finding is consistent with the findings of Kyriazopoulou, Karalis, Magos and Arvanitis (2022) who reported teachers' moderate knowledge regarding inclusive instruction. However, this current study's finding slightly contradicts Alemayehu (2020), who reported teachers' marginal knowledge of inclusion pedagogy. The results further showed that the teachers demonstrated a moderately higher knowledge of recognising individual learners' needs, learning experiences and levels of motivation and knowledge of using a variety of approaches that address learners' background, diversity and special needs as part of inclusion and equity pedagogy. This suggests that the teachers have an acceptable level of knowledge regarding embracing learners' needs, recognising their learning experiences and adopting different approaches that meet this diversity as part of accommodating all learners in the teaching and learning process.

As Florian (2014) maintains, by employing inclusive pedagogy, teachers are to ensure that all learners are supported by utilising approaches and creating a learning environment that benefits all learners. It was found that teachers'

demonstration of knowledge about ensuring that daily learning activities are quality and accessible to all learners was moderately lower. This seems to suggest that the teachers consider quality and accessibility less as part of inclusion and equity pedagogy. As emphasised in the NPECF (2018), learners are required to have access to quality education. This suggests that quality and accessibility are among the key areas of inclusion and pedagogy.

Pertaining to teachers' knowledge of differentiation and scaffolding pedagogy (KDSP), the teachers exhibited moderate knowledge. This indicates that the teachers possess an average level of knowledge about differentiation and scaffolding pedagogy. Consistent with this finding, Kyeremeh, Adzifome and Amoah (2022) reported in-service mathematics teachers' moderate knowledge of differentiated instruction. Similarly, this finding is in line with the finding of Mengistie (2020), who reported primary teachers' sufficient differentiated instruction knowledge. The results further revealed that the teachers exhibited moderately higher knowledge of differentiation as encompassing content, process, product, tasks, affect, learning environment and assessment, and knowledge of scaffolding learners' learning by using a variety of instructional techniques. This suggests that the teachers have substantial knowledge about differentiating in terms of content, process, product, tasks, learning environment and assessment. Tomlinson and Eidson (2003) are of the view that these are the means of ensuring that instruction is responsive to learners' diverse needs. Interestingly, the teachers demonstrated moderately lower knowledge about providing lesson vocabulary, exemplars and models as part of differentiation and scaffolding pedagogy. This appears to suggest that

the teachers' knowledge of using lesson vocabulary, exemplars and models to differentiate and scaffold learners' learning is moderately minimal.

Concerning teachers' knowledge of ICT as a pedagogical tool (KICTPT), the teachers demonstrated moderate knowledge. This suggests that the teachers have an appreciable level of knowledge about using ICT as a pedagogical tool. This finding agrees with Singh and Chan (2014) who reported teachers' moderate knowledge of ICT as a pedagogical tool. Similarly, consistent with this finding, Kamaruddin, Abdullah, Idris and Nawi (2017) reported teachers' sufficient knowledge about ICT as a tool for teaching and learning. However, contrary to this study's finding, Obielodan, Omojola, Tijani and Samuel (2020) reported teachers' low pedagogical knowledge about ICT. The findings of Mailizar and Fan (2020) also revealed teachers' inadequate knowledge about ICT and its utilisation in the teaching and learning process.

Regarding teachers' knowledge of ICT as a pedagogical tool (KICTPT), the results further revealed that the teachers demonstrated moderately higher knowledge of using ICT as a way of providing learners access to large quantities of information and increasing their level of motivation, competence and ability to apply ICT. As indicated by NaCCA (2019), utilising ICT as a tool in the teaching and learning process helps learners obtain a lot of information, increases their confidence and competence and offers the opportunity for learners to apply ICT. What this means is that when teachers exhibit knowledge of ICT and utilise it in teaching and learning, learners may stand the chance of increasing and deepening their knowledge and skills. However, a striking finding was that the teachers demonstrated moderately lower knowledge about the integration of ICT as a key tool under the standards-based mathematics

curriculum to enhance deep and independent learning. What this suggests is that the teachers appear to give minimal focus to the integration of ICT in the teaching and learning process.

Comparing the sub-dimensions addressing teachers' pedagogical knowledge, it was revealed that the teachers exhibited a moderately higher knowledge of inclusion and equity pedagogy (KIEP) compared to the remaining pedagogical approaches recommended for delivering the standards-based mathematics curriculum. This suggests that the teachers have slightly higher knowledge of KIEP than their knowledge of learner-centred pedagogy (KLCP), knowledge of differentiation and scaffolding (KDSP), and knowledge of ICT as a pedagogical tool (KICTPT). The results also point out that the teachers demonstrated a moderately lower knowledge of KICTPT. This suggests that the teachers appear to have little knowledge of ICT as a pedagogical tool compared to other sub-dimensions that address pedagogical knowledge of the standards-based mathematics curriculum.

Research Question 3: What is the pedagogical content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?

This research question sought to examine teachers' pedagogical content knowledge about the standards-based mathematics curriculum implementation. By pedagogical content knowledge, the researcher meant these two sub-dimensions: knowledge of learners' learning (KLL) and knowledge of recommended assessment practices (KRAP). On a dichotomous scale (1=true response; 0=false/not sure), teachers' knowledge was assessed to gather quantitative data. A "true response" received a score of 1, indicating knowledge,

while a "false" or "not sure" response received a score of 0, indicating a lack of knowledge. Mean, standard deviations, skewness and kurtosis of respondents' scores were used in the analysis and discussion of the quantitative data.

Based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the maximum mean score was considered as low knowledge, 34% -66.9% of the maximum mean score was viewed as moderate knowledge and $\geq 67\%$ of the maximum mean score was regarded as high knowledge. Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was considered as low knowledge, 0.34-0.66 implied moderate knowledge and 0.67-1.00 was regarded as high knowledge. However, assessing the overall knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was viewed as low knowledge, 1.36-2.69 was considered as moderate knowledge and 2.70-4.00 was regarded as high knowledge. Again, assessing the overall pedagogical content knowledge (PCK) by putting together the 2 sub-dimensions addressing PCK using 8 items, a mean score of 0.00-2.71 was considered as low knowledge, 2.72-5.35 was viewed as moderate knowledge, and 5.36-8.00 implied high knowledge of PCK of the standards-based mathematics curriculum. The results obtained for KLL and KRAP are presented in Tables 27 and 28 respectively.

Table 27: Teachers' Knowledge of Learners' Learning (KLL)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Teachers who understand learners' learning anticipate their conceptions, preconceptions and misconceptions and take time to address them.	803	.60	.491	-.394	.086	-1.849	.172
2. Understanding learners' learning entails awareness of learners' errors, learning needs, difficulties, and responses in the teaching and learning process.	803	.61	.489	-.437	.086	-1.814	.172
3. Teachers who understand learners' learning are aware of the background experiences learners bring to the classroom.	803	.64	.482	-.562	.086	-1.688	.172
4. Teachers who understand learners' learning adjust the pace of instruction to benefit everyone, interpret learners' misunderstandings and design tasks to further their understanding.	803	.60	.490	-.405	.086	-1.841	.172
Overall Knowledge of KLL	803	2.45	.971	-.072	.086	-.568	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 27, regarding teachers' knowledge of learners' learning (KLL), the results show teachers demonstrated moderately higher knowledge of background experiences learners bring to the classroom (M = .64; SD = .48) than their knowledge of learners' errors, learning needs, and learners' responses

in the teaching and learning process ($M = .61$; $SD = .48$) as part of KLL for delivering the standards-based mathematics curriculum. Teachers' knowledge about anticipating learners' conceptions, preconceptions and misconceptions ($M = .60$; $SD = .49$) and knowledge about adjusting the pace of instruction, interpreting learners' misunderstandings and designing tasks to foster their understanding ($M = .60$; $SD = .49$) were both moderately lower. Overall, teachers exhibited a moderate knowledge of learners' learning ($M = 2.45$; $SD = .97$) for delivering the standards-based mathematics curriculum. An inspection of the skewness and kurtosis values shows that the data is normally distributed since both skewness and kurtosis values lie within the range of ± 2 and ± 7 respectively (Kline, 2016). Table 28 presents the results of teachers' knowledge of recommended assessment practices.

Table 28: Teachers' Knowledge of Recommended Assessment Practices (KRAP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Under the new mathematics curriculum, assessment should entail using multiple and varied strategies to assess learners' learning and should reflect all the learning activities undertaken by the learner.	803	.62	.485	-.507	.086	-1.747	.172
2. Under the new mathematics curriculum, assessment entails providing timely and immediate feedback to learners before, during and after instruction.	803	.62	.485	-.507	.086	-1.747	.172

Table 28, Continued

3. Assessment entails informing stakeholders such as parents and guardians about the extent to which learners have attained the expected standards of the curriculum.	803	.58	.494	-.311	.086	-1.908	.172
4. An authentic way under the new mathematics curriculum is to use learners' portfolios, presentations, projects, observations, and interviews to assess learners' learning.	803	.61	.487	-.469	.086	-1.785	.172
Overall Knowledge of KRAP	803	2.43	1.042	-.203	.086	-.625	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 28 regarding teachers' knowledge of recommended assessment practices (KRAP) show that teachers exhibited a moderate knowledge of using multiple and varied strategies to assess all the learning activities undertaken by the learner ($M = .62$; $SD = .48$) and knowledge of providing timely and immediate feedback to learners before, during and after instruction ($M = .62$; $SD = .48$) as part of assessing learners' learning under the standards-based mathematics curriculum. Teachers' knowledge of informing stakeholders about the extent to which learners have attained the expected standards of the curriculum ($M = .58$; $SD = .49$) was moderately lower than their knowledge of assessing learners using portfolios, presentations, projects, observations, interviews, etc. ($M = .61$; $SD = .48$) as part of learners' assessment under the standards-based mathematics curriculum. Overall, teachers' knowledge of recommended assessment practices (KRAP) was moderate ($M = 2.43$; $SD = 1.04$). Examining the skewness and kurtosis values reveals that the

data is normally distributed because both values fall between ± 2 and ± 7 , respectively (Kline, 2016). Additionally, a comparison of teachers' knowledge of KLL and KRAP addressing pedagogical content knowledge was done. The results obtained are reported in Table 29.

Table 29: Comparison of Teachers' Knowledge of KLL and KRAP

Sub-dimension	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
KLL Scores	803	2.45	.971	-.072	.086	-.568	.172
KRAP Scores	803	2.43	1.042	-.203	.086	-.625	.172
Overall							
Knowledge of PCK	803	4.88	1.518	-.070	.086	-.354	.172

Source: Fieldwork, 2023; For each sub-dimension, a mean (M) score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge. For overall knowledge of PCK, a mean score of 0.00-2.71 = low knowledge; 2.72-5.35 = moderate knowledge; 5.36-8.00 = high knowledge

From Table 29, comparing teachers' knowledge of the 2 sub-dimensions addressing pedagogical content knowledge (PCK) about delivering the standards-based mathematics curriculum, the results reveal that teachers exhibited slightly higher moderate knowledge of KLL ($M = 2.45$; $SD = .97$) than their knowledge of KRAP ($M = 2.43$; $SD = 1.04$). The results further show that, overall, teachers' pedagogical content knowledge (PCK) in terms of KLL and KRAP was found to be moderately higher ($M = 4.88$; $SD = 1.51$). The data is normally distributed, as shown by the values for skewness and kurtosis, which both lie within ± 2 and ± 7 respectively (Kline, 2016).

Discussion of Results of Research Question 3

The overall results of research question 3 show that the teachers demonstrated a moderate level of pedagogical content knowledge of the standards-based mathematics curriculum in terms of their knowledge of learners' learning (KLL) and knowledge of recommended assessment practices (KRAP). This result appears to suggest that the teachers have a fair level of knowledge. As emphasised by Shulman (1986), teachers' knowledge of pedagogical content serves as one of the most useful knowledge which aids in the representation of the content. This suggests that for learners to appreciate the content, teachers need to master a lot of skills including pedagogical content knowledge.

As explained in the National Teacher Education Curriculum Framework (NTECF, 2017), teachers' PCK knowledge provides a basis for teachers to understand learners and their learning. Rogan and Grayson (2003) contend that teachers' implementation of curriculum could be impacted when they lack sufficient knowledge. This suggests that when teachers demonstrate sufficient knowledge of PCK, it could help them understand how learners learn and improve implementation. Relating Rogan and Grayson's (2003) concept of "capacity to innovate" in terms of teachers' knowledge to this study's findings, on average, it implies that the teachers are demonstrating an appreciable level of pedagogical content knowledge about the implementation of the standards-based mathematics curriculum.

Regarding the teachers' knowledge of learners' learning (KLL), the teachers demonstrated a moderate level of knowledge. This implies the teachers showed an average level of knowledge about how learners learn. Consistent

with this study's findings, Essa and El-Zeftawy (2015) reported teachers' fair knowledge of learners' learning in terms of their knowledge of identifying learners' learning difficulties as part of learners' learning. The findings further revealed that the teachers exhibited moderately higher knowledge of recognising learners' background experiences they bring to the classroom as part of their learning. As maintained by NaCCA (2019), teachers are to link the delivery of the standards-based curriculum to learners' background experiences which presents teachers with opportunities to appreciate learners' frame of understanding. This suggests that teachers could effectively activate learners' learning when they have sufficient knowledge of learners' prior experiences. As pointed out by Dochy, De Rijdt and Dyck (2002), understanding learners' prior knowledge and experiences influences new learning. This implies that when teachers are knowledgeable about learners' backgrounds and prior experiences, it could facilitate the easy activation of learners' learning.

It was found that the teachers' knowledge of learners' errors, learning needs, learners' responses in the teaching and learning process, and knowledge of anticipating learners' conceptions, preconceptions and misconceptions as part of the knowledge of learners' learning was moderately lower. This finding is consistent with Kılıç (2011) who reported teachers' insufficient knowledge of learners' learning regarding their inability to analyse learners' learning errors as part of learners' learning. In agreement with this finding, Çelik and Güzel (2017) reported mathematics teachers' inadequate knowledge of noticing learners' errors and misconceptions as part of learners' learning. Similarly, this finding is in line with Morrison and Lederman (2003) who reported teachers' inadequate knowledge of diagnosing learners' preconceptions. This finding

relating to this study seems to suggest that the teachers' knowledge of appreciating learners' learning needs, errors, preconceptions, and misconceptions as part of learners' learning is insufficient.

Concerning the teachers' knowledge of recommended assessment practices (KRAP), the findings point to the teachers' exhibition of moderate knowledge. This implies that the teachers demonstrated a fair knowledge of assessment practices recommended in the standards-based mathematics curriculum. This finding shows consistency with Matsenjwa and Thwala (2013) who reported teachers' knowledge of assessment practices. However, it contradicts Akayuure (2021) who reported that most mathematics teachers do not meet the literacy assessment requirement standards. In contrast to this study's findings, Amoako, Asamoah and Bortey (2019) also reported mathematics teachers' low knowledge about assessment practices. Again, contrary to what was found in this current study, Yamtim and Wongwanich (2014) reported teachers' low knowledge about assessment literacy. Gani and Mahjaty (2017) further revealed teachers' low knowledge of standards of evaluation about the new 2013 curriculum which shows a contradiction to this current study's finding. These findings seem to suggest that teachers possess low knowledge of assessment practices which contradicts this current study's finding.

The current study's findings further revealed that the teachers demonstrated a moderate knowledge of using multiple and varied strategies to assess all the learning activities undertaken by the learner and knowledge of providing timely and immediate feedback to learners before, during and after instruction. This suggests that the teachers exhibited a fair knowledge about

assessing learners' learning which requires using multiple and varied strategies under the standards-based mathematics curriculum. Also, it points out that the teachers have a fair knowledge about giving learners prompt and timely feedback regarding their learning before, during and after teaching. As emphasised in the NPECF (2018), the authentic way of assessing learners under the standards-based curriculum is by employing different assessment techniques such as learners' observations, anecdotal records, interviews, portfolios and projects. This implies that teachers are expected not to solely rely on one technique of assessment. Further, as maintained by NaCCA (2019), in the delivery of the standards-based curriculum, teachers are expected to communicate the progress of the learner's learning before, during and after instruction.

It was found that the teachers' knowledge of informing stakeholders about the extent to which learners have attained the expected standards of the curriculum was moderately lower. This appears that the teachers' knowledge of communicating to stakeholders such as parents and guardians about the extent to which learners have attained the expected standards of the curriculum was insufficient. As emphasised by Poth (2012), assessment entails communicating with students, their parents and other relevant parties. This implies information gathered from assessment regarding learners' performance is expected to be communicated to the learners themselves, their parents or guardians and other relevant stakeholders for informed decision making.

Comparing the sub-dimensions addressing teachers' pedagogical content knowledge, it was found that the teachers demonstrated a moderately higher knowledge of learners' learning (KLL) than their knowledge of

recommended assessment practices (KRAP). This suggests that the teachers appear to have greater knowledge of learners' learning compared to their knowledge of recommended assessment practices regarding the standards-based mathematics curriculum.

Research Question 4: What is the contextual knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?

This research question sought to examine teachers' contextual knowledge (CtK) about the standards-based mathematics curriculum implementation. By contextual knowledge, the researcher meant these two sub-dimensions: knowledge of learning contexts (classroom, school, community and culture) (KLC) and knowledge of the learner (KL). On a dichotomous scale (1=true response; 0=false/not sure), teachers' knowledge was assessed to gather quantitative data. A "true response" received a score of 1, indicating knowledge, while a "false" or "not sure" response received a score of 0, indicating a lack of knowledge. Mean, standard deviations, skewness and kurtosis of respondents' scores were used for analysing and discussing the quantitative data.

Based on the dichotomous scale (1= true; 0= false/not sure) and using the Zaidi et al. (2021) adjusted criteria for assessing knowledge, $\leq 33.9\%$ of the maximum mean score was considered as low knowledge, $34\% - 66.9\%$ of the maximum mean score was viewed as moderate knowledge and $\geq 67\%$ of the maximum mean score was regarded as high knowledge. Hence, for each item addressing a particular sub-dimension, a mean score of 0.00-0.33 was considered as low knowledge, 0.34-0.66 implied moderate knowledge and 0.67-1.00 was regarded as high knowledge. However, assessing the overall

knowledge of each sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-1.35 was viewed as low knowledge, 1.36-2.69 was considered as moderate knowledge and 2.70-4.00 was regarded as high knowledge. Again, assessing the overall contextual knowledge (CtK) by putting together the 2 sub-dimensions addressing CtK using 8 items, a mean score of 0.00-2.71 was regarded as low knowledge, 2.72-5.35 was considered as moderate knowledge and 5.36-8.00 implied high knowledge of CtK of the standards-based mathematics curriculum. The results obtained for KLC and KL are displayed in Tables 30 and 31 respectively.

Table 30: Teachers' Knowledge of Learning Contexts (KLC)

Item	N	M	SD	Skewness Statistic	Std. Error	Kurtosis Statistic	Std. Error
1. Valuable information about learners for effective delivery of the new mathematics curriculum is found in learners' communities.	803	.59	.492	-.368	.086	-1.869	.172
2. Teaching and learning become meaningful to learners when connected to learners' socio-cultural backgrounds, experiences and practices.	803	.58	.494	-.331	.086	-1.895	.172
3. Teaching and learning activities should be situated in learners' real-life contexts and pre-existing knowledge to which they can relate.	803	.60	.491	-.389	.086	-1.853	.172

Table 30, Continued

4. A conducive, well-managed and orderly learning classroom atmosphere facilitates effective curriculum delivery.	803	.62	.486	-.485	.086	-1.769	.172
Overall Knowledge of KLC	803	2.39	1.039	-.279	.086	-.457	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

The results in Table 30 regarding teachers' knowledge of learning contexts (classroom, school, community and culture) about the standards-based mathematics curriculum implementation show that teachers demonstrated moderately higher knowledge about a well-managed and orderly classroom for facilitating effective curriculum delivery ($M = .62$; $SD = .48$) than their knowledge about situating teaching and learning in learners' real-life contexts and pre-existing knowledge ($M = .60$; $SD = .49$). Teachers' knowledge about utilising information from learners' communities ($M = .59$; $SD = .49$) and knowledge about connecting teaching and learning to learners' socio-cultural background, experiences and practices ($M = .58$; $SD = .49$) as part of delivering the standards-based curriculum were moderately lower. Overall, the results reveal that teachers demonstrated a moderate ($M = 2.39$; $SD = 1.03$) knowledge of learning contexts (classroom, school, community and culture) about the standards-based mathematics curriculum implementation. The skewness and kurtosis values show the data is normally distributed since both values are within the range of ± 2 and ± 7 respectively (Kline, 2016). Table 31 presents the results of teachers' knowledge of the learner.

Table 31: Teachers' Knowledge of the Learner (KL)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. Knowledge of learners' characteristics is a key component for effective instructional practices.	803	.62	.485	-.502	.086	-1.753	.172
2. Teachers who are good are aware of their learners' learning styles, motivation, abilities and strengths in the teaching and learning process.	803	.60	.490	-.421	.086	-1.828	.172
3. Learners' own emotions and beliefs affect the effective delivery of a curriculum.	803	.57	.496	-.264	.086	-1.935	.172
4. Learners' interests, prior experiences and background knowledge are essential for effective curriculum delivery.	803	.56	.497	-.234	.086	-1.950	.172
Overall Knowledge of KL	803	2.35	.972	-.088	.086	-.514	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-0.33 = low knowledge; 0.34-0.66 = moderate knowledge; 0.67-1.00 = high knowledge. For overall knowledge; a mean score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge

From Table 31, concerning teachers' knowledge of the learner (KL) as part of delivering the standards-based mathematics curriculum, teachers exhibited a moderate knowledge of learners' characteristics for effective instructional practices ($M = .62$; $SD = .48$) and knowledge of learners' learning styles, motivation, and abilities ($M = .60$; $SD = .49$). However, teachers' knowledge about learners' own emotions and beliefs ($M = .57$; $SD = .49$) and knowledge about learners' interests, prior experiences and background ($M = .56$; $SD = .49$) for effective curriculum delivery were moderately lower. Overall, teachers' knowledge of the learner (KL) was moderate ($M = 2.35$; $SD = .97$).

The skewness and kurtosis values show that the data is normally distributed because both values fall within the range of ± 2 and ± 7 respectively (Kline, 2016). In addition, a comparison of teachers' knowledge of KLC and KL addressing contextual knowledge was done. The results obtained are reported in Table 32.

Table 32: Comparison of Teachers' Knowledge of KLC and KL

Sub-dimension	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
KLC Scores	803	2.39	1.039	-.279	.086	-.457	.172
KL Scores	803	2.35	.972	-.088	.086	-.514	.172
Overall Knowledge of CtK	803	4.73	1.562	-.150	.086	-.011	.172

Source: Fieldwork, 2023; For each sub-dimension, a mean (M) score of 0.00-1.35 = low knowledge; 1.36-2.69 = moderate knowledge; 2.70-4.00 = high knowledge. For overall knowledge of CtK, a mean score of 0.00-2.71 = low knowledge; 2.72-5.35 = moderate knowledge; 5.36-8.00 = high knowledge

From Table 32, comparing teachers' knowledge of the 2 sub-dimensions addressing contextual knowledge (CtK) about delivering the standards-based mathematics curriculum, the results show that teachers demonstrated a slightly higher moderate knowledge of learning contexts (KLC) ($M = 2.39$; $SD = 1.03$) than knowledge of the learner (KL) ($M = 2.35$; $SD = .97$). The results further show that, overall, teachers' contextual knowledge (CtK) in terms of KLC and KL was found to be moderately higher ($M = 4.73$; $SD = 1.56$). The skewness and kurtosis values indicate that the data is normally distributed because both values fall within the range of ± 2 and ± 7 respectively (Kline, 2016).

Discussion of Results of Research Question 4

Overall, the results of research question 4 show that teachers demonstrated a moderate level of contextual knowledge in terms of their knowledge of learning contexts (classroom, school, community and culture) and knowledge of the learner regarding the standards-based mathematics curriculum implementation. This finding seems to suggest that the teachers possessed a fair contextual knowledge concerning the delivery of the standards-based mathematics curriculum. As emphasised by Shulman (1987), teachers need to appreciate the context within which teaching and learning occur. This involves being familiar with the school, classroom environment, culture and community where the school operates and learners learn. As maintained by the National Teacher Education Curriculum Framework (NTECF, 2017), teachers need contextual knowledge to respond to the increasingly diverse learning environment.

Rogan and Grayson (2003) assert that teachers' curriculum implementation could be influenced when they lack sufficient knowledge. This implies that teachers are expected to understand the diverse contexts in which learning occurs to meet the various backgrounds of the learners. It thus suggests that when teachers demonstrate sufficient contextual knowledge, it could serve as a means of connecting and situating learning to meet different learners' needs. Johnson (2002) opines that when teaching and learning are done contextually, it makes instruction meaningful to learners in the sense that learners can connect instruction to a real-world situation. Relating Rogan and Grayson's (2003) idea of "capacity to innovate" in terms of teachers' knowledge to this study's findings, on average, it could be inferred that the teachers are

demonstrating an appreciable level of contextual knowledge about the implementation of the standards-based mathematics curriculum.

Regarding the teachers' knowledge of learning contexts (classroom, school, community, and culture) (KLC) about the delivery of the standards-based mathematics curriculum, overall, the teachers exhibited a moderate level of knowledge. This finding seems to suggest that the teachers have sufficient knowledge of learning contexts for delivering the standards-based mathematics curriculum. However, this finding contradicts Amesi, Akpomi and Amadi (2014) who reported teachers' insufficient knowledge of learning context issues. Also, contrary to this finding, Siddiqui and Ahamed (2020) revealed teachers' low knowledge regarding the social and cultural backgrounds of learners. As maintained by NaCCA (2019), teachers are to contextualise the teaching and learning of the standards-based mathematics curriculum as a means of helping learners construct their knowledge and understanding. Therefore, this study's finding implies that teachers are expected to situate the delivery of the standards-based mathematics curriculum in learners' learning contexts such as the classroom, school, community and cultural environments.

Analysing each finding from the KLC individually, it was observed that the teachers demonstrated greater knowledge in certain learning contexts than others. For instance, it was found that the teachers demonstrated moderately higher knowledge about the classroom learning context as a means of facilitating effective curriculum delivery than their knowledge about situating teaching and learning in learners' real-life contexts and pre-existing knowledge, learners' communities, and socio-cultural background, experiences and practices. What this seems to suggest is that the teachers appear to show

insufficient knowledge about situating and connecting the delivery of the standards-based mathematics curriculum to learners' communities and socio-cultural background experiences. As pointed out by Vygotsky (1987), learners' rich experiences from their socio-cultural environment provide the impetus to link learners' every concept to school mathematics. It thus suggests that, when teachers have a total grasp of students' cultural activities, it becomes possible to link everyday mathematics concepts and school mathematics concepts. Researchers of ethnomathematics (Ascher, 1991; Bishop, 1988; D'Ambrosio, 1985; Pompeu, 1994; Presmeg, 1996a) also point to the cultural nature of mathematics. This suggests the essence of connecting the delivery of the standards-based mathematics curriculum to learners' real-life experiences, communities and socio-cultural contexts of learning.

Concerning the teachers' knowledge of the learner (KL) regarding the delivery of the standards-based mathematics curriculum, overall, the teachers' knowledge was moderate. This finding seems to suggest that the teachers have a fair knowledge of the learners. The study's finding is consistent with Mayer and Marland (1997) who reported teachers' sufficient knowledge about the students they teach. The study's finding implies that teachers demonstrating sufficient knowledge of the learner are key to delivering the standards-based mathematics curriculum. As emphasised by Mayer and Marland (1997), possessing knowledge of students is a vital ingredient for effective teaching and learning as it helps to understand learners' learning styles, present knowledge, learning needs, social and cultural backgrounds, beliefs, values and attitudes as well as learners' motivation for learning. This suggests that teachers could

implement the standards-based mathematics curriculum effectively when they demonstrate good knowledge of the learner in the teaching and learning process.

Examining each of the KL's findings individually, it was revealed that the teachers demonstrated moderately higher knowledge about learners' characteristics, learners' learning styles, motivation, and abilities for the standards-based mathematics curriculum delivery. This finding seems to suggest that the teachers have sufficient knowledge about learners' characteristics, learning styles, motivation and abilities. In the view of Dunn, Griggs, Olson, Gorman and Beasley (1995), knowledge of students such as their characteristics and learning styles helps to adjust teaching and learning to suit them which improves gains. The study's finding implies that when teachers demonstrate adequate knowledge of the learner, it could serve as a means of activating learners' learning for effective delivery of the standards-based mathematics curriculum.

Regarding teachers' knowledge of the learner (KL), it was found that the teachers demonstrated moderately lower knowledge of learners' own emotions and beliefs, interests, prior experiences and background concerning the standards-based curriculum delivery. This finding appears to suggest that the teachers do not show sufficient knowledge that learners' own emotions and beliefs, interests, prior experiences and background affect the effective delivery of the standards-based mathematics curriculum. As recommended in the National Pre-tertiary Education Curriculum Framework (NPECF, 2018), teachers are expected to maximise instruction to benefit every learner by linking teaching and learning to learners' prior experiences, background knowledge, and interests. Therefore, the study's finding implies that teachers' knowledge

needs to be strengthened to appreciate that learners' own emotions and beliefs, interests, prior experiences and background could affect how effectively they deliver the standards-based mathematics curriculum.

Research Question 5: What is the extent of basic school teachers' implementation of the standards-based mathematics curriculum in the Techiman Municipality?

This research question sought to assess the extent of basic school teachers' implementation of the standards-based mathematics curriculum. Nine (9) sub-dimensions were assessed regarding the extent of teachers' implementation of the standards-based mathematics curriculum. These included implementing the curriculum's organisation and structure, expected learning behaviours, instructional expectations, core competencies, learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy, ICT implementation and recommended assessment practices implementation. On a 5-point Likert scale (0=never, 1=almost never, 2=occasionally, 3=almost every time, 4=every time), teachers' implementation of the standards-based mathematics curriculum was assessed to gather quantitative data. "Never" attracted a score of 0, "almost never" had a score of 1, "occasionally" with a score of 2, "almost every time" had a score of 3, and "every time" with a score of 4. Mean, standard deviations, skewness and kurtosis of respondents' scores were used for analysing and discussing the quantitative data.

Based on the 5-point Likert scale and using the Rosecrans et al. (2008) adjusted criteria for assessing implementation, $\leq 49.9\%$ of the maximum mean score was considered as low implementation, 50% -74.9% of the maximum

mean score was regarded as moderate implementation and $\geq 75\%$ of the maximum mean score was viewed as high implementation. Hence, for each item addressing a particular sub-dimension implementation, a mean score of 0.00-1.99 was regarded as low implementation, 2.00-2.99 was viewed as moderate implementation and 3.00-4.00 was considered as high implementation. However, assessing the overall implementation of the sub-dimension of the curriculum's organisation and structure using 2 items, a mean score of 0.00-3.99 was regarded as low implementation, 4.00-5.99 was considered as moderate implementation and 6.00-8.00 was viewed as high implementation. Apart from this, assessing the overall implementation of each remaining sub-dimension using 4 items addressing each sub-dimension, a mean score of 0.00-7.99 was considered as low implementation, 8.00-11.99 was viewed as moderate implementation and 12.00-16.00 was regarded as high implementation.

Again, assessing the overall implementation of the curriculum by putting together the 9 sub-dimensions addressing the implementation using 34 items, a mean score of 0.00-67.99 was regarded as low implementation, 68.00-101.99 was viewed as moderate implementation, and 102.00-136.00 was considered as high implementation of the standards-based mathematics curriculum. The results obtained on the various sub-dimensions addressing the teachers' implementation of the standards-based mathematics curriculum are displayed in Tables 33, 34, 35, 36, 37, 38, 39, 40, and 41.

Table 33: Teachers' Implementation of the Organisation and Structure of the Curriculum (OSC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I consider the strands, sub-strands, content standards, indicators, and exemplars before planning my lesson.	803	2.02	1.377	-.436	.086	-1.222	.172
2. I consider the annotations when preparing my lesson.	803	2.04	1.339	-.483	.086	-1.112	.172
Overall implementation of OSC	803	4.06	1.835	-.211	.086	-.481	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-3.99 = low implementation; 4.00-5.99 = moderate implementation; 6.00-8.00 = high implementation

The results in Table 33 regarding teachers' implementation of the organisation and structure of the standards-based mathematics curriculum show that the teachers demonstrated a moderate implementation of the strands, sub-strands, content standards, indicators, and exemplars ($M = 2.02$; $SD = 1.37$) and the annotations ($M = 2.04$; $SD = 1.33$). Overall, teachers' implementation of the organisation and structure of the curriculum (OSC) was moderate ($M = 4.06$; $SD = 1.83$). The skewness and kurtosis values also show that the data is normally distributed since both values lie within ± 2 and ± 7 respectively (Kline, 2016). Table 34 presents the results of teachers' implementation of the expected learning behaviours.

Table 34: Teachers' Implementation of the Expected Learning Behaviours (ELB)

Item	N	M	SD	Skewness Statistic	Std. Error	Kurtosis Statistic	Std. Error
1. I engage learners to analyse, synthesise, evaluate and create new ideas in a mathematics lesson	803	2.02	1.313	-.507	.086	-1.125	.172
2. I engage learners to develop the skills of observing, classifying, comparing, communicating, reporting, predicting, and interpreting	803	2.04	1.337	-.497	.086	-1.140	.172
3. I engage learners in mathematics activities/tasks that develop their attitudes and values	803	1.99	1.373	-.426	.086	-1.269	.172
4. I engage learners to develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness	803	2.02	1.342	-.474	.086	-1.173	.172
Overall Implementation of ELB	803	8.07	2.645	-.119	.086	-.143	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

From Table 34, the results of teachers' implementation of the expected learning behaviour (ELB) as part of delivering the standards-based mathematics curriculum reveal that the teachers exhibited moderately higher implementation of developing learners' skills in observing, classifying, comparing, communicating, reporting, predicting and interpreting ($M = 2.04$; $SD = 1.33$) as

compared to their implementation of engaging learners to analyse, synthesise, evaluate and create ($M = 2.02$; $SD = 1.31$) and developing learners' commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility and environmental awareness ($M = 2.02$; $SD = 1.34$). Further, teachers demonstrated a low implementation of engaging learners in mathematics activities to develop their attitudes and values ($M = 1.99$; $SD = 1.37$). Overall, teachers' implementation of the expected learning behaviours was moderate ($M = 8.07$; $SD = 2.64$). Assessing the skewness and kurtosis values shows the data is normally distributed since both values are within the range of ± 2 and ± 7 respectively (Kline, 2016). Table 35 displays the results of teachers' implementation of the instructional expectations of the curriculum.

Table 35: Teachers' Implementation of the Instructional Expectations of the Curriculum (IEC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I engage learners to construct their own knowledge and understanding in mathematics lessons.	803	1.98	1.329	-.469	.086	-1.180	.172
2. I act as a facilitator and engage learners to discuss their ideas in a mathematics lesson.	803	2.04	1.355	-.429	.086	-1.163	.172
3. I expose learners to mathematical situations, tasks and activities that challenge them in deep and profound mathematics learning.	803	2.04	1.331	-.508	.086	-1.128	.172

Table 35, Continued

4. I make learners work together as colleagues and generate discourse among themselves in a mathematics lesson.	803	2.11	1.360	-.518	.086	-1.073	.172
Overall Implementation of IEC	803	8.17	2.737	-.184	.086	-.056	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

The results in Table 35 regarding teachers' implementation of the instructional expectations of the standards-based mathematics curriculum show that teachers demonstrated moderately higher implementation of making learners work together as colleagues and generating discourse among themselves in mathematics lessons ($M = 2.11$; $SD = 1.36$) than their implementation of acting as facilitators ($M = 2.04$; $SD = 1.35$) and exposing learners to mathematics activities that challenge them in profound learning ($M = 2.04$; $SD = 1.33$). The results further reveal that teachers exhibited a low implementation ($M = 1.98$; $SD = 1.32$) of engaging learners as constructors of their own knowledge and understanding. Overall, teachers exhibited a moderate implementation of the instructional expectations of the curriculum ($M = 8.17$; $SD = 2.73$). The skewness and kurtosis values indicate that the data is normally distributed because both values fall within the range of ± 2 and ± 7 respectively (Kline, 2016). Table 36 represents the results of teachers' implementation of the core competencies.

Table 36: Teachers' Implementation of the Core Competencies (CC)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I engage learners in problem-solving and problem-posing activities to develop their critical thinking skills.	803	2.01	1.410	-.401	.086	-1.308	.172
2. I engage learners in mathematical inquiry to make them creative and innovative.	803	2.06	1.358	-.477	.086	-1.129	.172
3. I engage learners actively to participate, communicate and collaborate in sharing their ideas in a mathematics lesson.	803	2.09	1.456	-.418	.086	-1.293	.172
4. I engage learners in self-awareness and self-esteem in a mathematics lesson.	803	2.03	1.428	-.370	.086	-1.312	.172
Overall Implementation of CC	803	8.19	2.820	-.180	.086	-.080	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

From Table 36 regarding teachers' implementation of the core competencies as part of delivering the standards-based mathematics curriculum, the results show teachers demonstrated moderately higher implementation of engaging learners actively to participate, communicate and collaborate in sharing their ideas in mathematics lessons ($M = 2.09$; $SD = 1.45$) than engaging learners in mathematical inquiry to make them creative and innovative ($M = 2.06$; $SD = 1.35$). Teachers' implementation of engaging learners in problem-solving and problem-posing activities to develop their critical thinking skills ($M = 2.01$; $SD = 1.41$) was moderately lower than their implementation of engaging

learners in self-awareness and self-esteem in mathematics lessons ($M = 2.03$; $SD = 1.42$). Overall, teachers' implementation of the core competencies was moderate ($M = 8.19$; $SD = 2.82$). Further analysis of the skewness and kurtosis values indicates the data is normally distributed because both values are within the range of ± 2 and ± 7 respectively (Kline, 2016). Table 37 shows the results of teachers' implementation of learner-centred pedagogy.

Table 37: Teachers' Implementation of Learner-Centred Pedagogy (LCP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I engage learners in meaningful hands-on activities during a mathematics lesson.	803	2.09	1.378	-.527	.086	-1.142	.172
2. I engage learners in problem-solving activities, inquiry-based activities, investigative-based activities, project-based activities, discovery activities/work, group work and group discussion, creative-based activities/work, and think-pair-share activities in a mathematics lesson.	803	2.05	1.377	-.474	.086	-1.181	.172
3. I involve learners actively in a mathematics lesson, working in groups, solving and looking for answers on their own rather than providing the answers.	803	2.05	1.368	-.492	.086	-1.171	.172
4. I make learners take ownership of their learning in mathematics lessons to construct their own knowledge.	803	2.03	1.351	-.473	.086	-1.169	.172
Overall Implementation of LCP	803	8.22	2.868	-.134	.086	-.465	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

The results in Table 37 on teachers' implementation of learner-centred pedagogy reveal that teachers demonstrated moderately higher implementation of engaging learners in meaningful hands-on activities during mathematics lessons ($M = 2.09$; $SD = 1.37$), involving learners actively in mathematics lessons and working in groups ($M = 2.05$; $SD = 1.36$) and engaging learners in activities such as inquiry-based, problem-solving, project-based, creative-based activities, etc. ($M = 2.05$; $SD = 1.37$). The results further show that teachers' implementation of making learners take ownership of their learning in mathematics lessons to construct their knowledge was moderately low ($M = 2.03$; $SD = 1.35$). Overall, teachers demonstrated a moderate implementation of the learner-centred pedagogy ($M = 8.22$; $SD = 2.86$). An examination of the skewness and kurtosis values reveals that the data is normally distributed since both values of skewness and kurtosis lie within ± 2 and ± 7 respectively (Kline, 2016). Table 38 presents the results of teachers' implementation of inclusion and equity pedagogy

Table 38: Teachers' Implementation of Inclusion and Equity Pedagogy (IEP)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I give access to all learners and ensure that mathematics learning activities are accessible to all learners.	803	2.06	1.341	-.510	.086	-1.112	.172
2. I engage learners using a variety of approaches to address learners' diversity, special needs, abilities and potentials in a mathematics lesson.	803	2.10	1.341	-.553	.086	-1.050	.172

Table 38, continued

3. I accommodate learners' learning styles, interests and readiness during mathematics instruction to make all learners have the best possible chance of learning.	803	2.16	1.282	-.650	.086	-.835	.172
4. I engage learners through their learning needs, learning experiences, background, and levels of motivation in planning and delivering a mathematics lesson.	803	2.24	1.308	-.713	.086	-.772	.172
Overall Implementation of IEP	803	8.56	2.871	-.337	.086	-.189	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

From Table 38 on teachers' implementation of inclusion and equity pedagogy, the results show that teachers demonstrated moderately higher implementation of engaging learners through their learning experiences, needs, background and levels of motivation ($M = 2.24$; $SD = 1.30$) as compared to accommodating learners' learning styles, interests and readiness ($M = 2.16$; $SD = 1.28$), and engaging learners using a variety of approaches to address their diversity, special needs and abilities during mathematics lessons ($M = 2.10$; $SD = 1.34$). The results further show that giving access to all learners during mathematics activities was the least moderately implemented ($M = 2.06$; $SD = 1.34$). Overall, teachers demonstrated a moderate implementation of inclusion and equity pedagogy ($M = 8.56$; $SD = 2.87$). Both skewness and kurtosis values lie within the range of ± 2 and ± 7 respectively, indicating that the data is

normally distributed (Kline, 2016). Table 39 shows the results of teachers' implementation of differentiation and scaffolding pedagogy.

Table 39: Teachers' Implementation of Differentiation and Scaffolding Pedagogy (DSP)

Item	N	M	SD	Skewness Statistic	Std. Error	Kurtosis Statistic	Std. Error
1. I break down content, tasks and mathematics learning activities for learners' different abilities to ensure that they are accessible and adequately benefit every learner.	803	2.14	1.376	-.482	.086	-1.077	.172
2. I allow learners to respond to tasks at different levels and move progressively towards a stronger understanding and greater independence.	803	2.15	1.308	-.565	.086	-.893	.172
3. I provide learners with mathematical vocabulary and exemplars, offer a simplified version of mathematics lessons and gradually increase the sophistication over time.	803	2.17	1.298	-.603	.086	-.829	.172
4. I use multiple ways to engage learners to enhance their understanding.	803	1.98	1.411	-.285	.086	-1.273	.172
Overall Implementation of DSP	803	8.44	2.963	-.152	.086	-.434	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

The results in Table 39 regarding teachers' implementation of differentiation and scaffolding pedagogy show that teachers exhibited

moderately high implementation of providing learners with mathematics vocabulary and exemplars and simplifying mathematics lessons ($M = 2.17$; $SD = 1.29$), followed by allowing learners to respond to tasks at different levels ($M = 2.15$; $SD = 1.30$) and breaking down content, tasks and mathematics learning activities for learners with different abilities ($M = 2.14$; $SD = 1.37$). The results further reveal that teachers demonstrated a low implementation of engaging learners with multiple ways to enhance their understanding ($M = 1.98$; $SD = 1.41$). Overall, teachers exhibited a moderate implementation of differentiation and scaffolding pedagogy ($M = 8.44$; $SD = 2.96$). The data is normally distributed since the values for skewness and kurtosis are within the ranges of ± 2 and ± 7 , respectively (Kline, 2016). Table 40 displays the results of teachers' implementation of ICT.

Table 40: Teachers' Implementation of ICT (ICT)

Item	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
1. I make use of ICT to enhance learners' deep and independent learning in mathematics lessons.	803	1.32	1.035	.088	.086	-1.047	.172
2. I support learners using multimedia such as audio, graphics, animation, and videos during a mathematics lesson.	803	1.47	1.011	-.127	.086	-.965	.172
3. I use ICT to support learners in accessing information online in a mathematics lesson.	803	1.35	.980	.011	.086	-.844	.172

Table 40, continued

4. I make learners organise mathematics activities using ICT to enhance their level of creativity and motivation.	803	1.41	1.047	.028	.086	-.950	.172
Overall Implementation of ICT	803	5.55	2.750	.095	.086	-.149	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

The results in Table 40 regarding teachers' implementation of ICT show that teachers demonstrated low implementation of supporting learners with multimedia during mathematics lessons ($M = 1.47$; $SD = 1.01$), followed by making learners organise mathematics activities using ICT to enhance their creativity ($M = 1.41$; $SD = 1.04$) and supporting learners to access information using ICT during mathematics lesson ($M = 1.35$; $SD = .98$). The results further show that using ICT to enhance learners' independence during mathematics lessons received low implementation ($M = 1.32$; $SD = 1.03$). Overall, teachers demonstrated low implementation of ICT ($M = 5.55$; $SD = 2.75$). An inspection of the skewness and kurtosis values shows that the data is normally distributed since both skewness and kurtosis values lie within ± 2 and ± 7 respectively (Kline, 2016). Table 41 presents the results of teachers' implementation of recommended assessment practices.

Table 41: Teachers' Implementation of Recommended Assessment Practices (RAP)

Item	N	M	SD	Skewness Statistic	Std. Error	Kurtosis Statistic	Std. Error
1. I make use of learners' portfolios, project work, presentations, observations, interviews, and diaries to assess learners' achievement of the curriculum standards and other learning progress.	803	2.13	1.194	-.707	.086	-.566	.172
2. I engage learners individually and in groups to assess their attainment of the core competencies, 4Rs, attitudes, values and other learning outcomes.	803	2.21	1.136	-.844	.086	-.202	.172
3. I assess learners' learning at all stages of the lesson to cover all learning activities undertaken by the learner.	803	2.30	1.211	-.841	.086	-.329	.172
4. I make use of feedback from learners' assessments to improve their learning.	803	2.37	1.376	-.671	.086	-.785	.172
Overall implementation of RAP	803	9.01	2.824	-.453	.086	-.094	.172

Source: Fieldwork, 2023; For each item, a mean (M) score of 0.00-1.99 = low implementation; 2.00-2.99 = moderate implementation; 3.00-4.00 = high implementation. For overall implementation; a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation

The results in Table 41 concerning teachers' implementation of recommended assessment practice of the standards-based mathematic curriculum show that teachers demonstrated moderately high implementation of using feedback from learners' assessment to improve their learning (M =

2.37; SD = 1.37), followed by assessing learners' learning at all stages of lessons and covering all learning activities undertaken by learners (M = 2.30; SD = 1.21), and assessing learners individually and in groups (M = 2.21; SD = 1.13). The results further show that assessing learners' learning using their portfolios, project work, presentations and interviews was the least moderately implemented (M = 2.13; SD = 1.19). Overall, teachers exhibited moderately high implementation of the recommended assessment practices (M = 9.01; SD = 2.82) of the standards-based mathematics curriculum. The skewness and kurtosis values show the data is normally distributed since both values are found within ± 2 and ± 7 respectively (Kline, 2016). Additionally, a comparison of sub-dimensions addressing the implementation of the standards-based mathematics curriculum (SBMC) was done. The results obtained are displayed in Table 42.

Table 42: Comparison of Sub-dimensions Addressing Standards-based Mathematics Curriculum Implementation

Sub-Dimension	N	M	SD	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
OSC implementation	803	4.06	1.835	-.211	.086	-.481	.172
ELB implementation	803	8.07	2.645	-.119	.086	-.143	.172
IEC implementation	803	8.17	2.737	-.184	.086	-.056	.172
CC implementation	803	8.19	2.820	-.180	.086	-.080	.172
LCP implementation	803	8.22	2.868	-.134	.086	-.465	.172
IEP implementation	803	8.56	2.871	-.337	.086	-.189	.172
DSP implementation	803	8.44	2.963	-.152	.086	-.434	.172
ICT implementation	803	5.55	2.750	.095	.086	-.149	.172
RAP implementation	803	9.01	2.824	-.453	.086	-.094	.172
Overall implementation of SBMC	803	68.27	13.790	-.291	.086	.858	.172

Source: Fieldwork, 2023; For OSC sub-dimension, a mean (M) score of 0.00-3.99 = low implementation; 4.00-5.99 = moderate implementation; 6.00-8.00 = high implementation. For the remaining sub-dimensions, a mean score of 0.00-7.99 = low implementation; 8.00-11.99 = moderate implementation; 12.00-16.00 = high implementation. For overall implementation; a mean score of 0.00-67.99 = low implementation; 68.00-101.99 = moderate implementation; 102.00-136.00 = high implementation

From Table 42, comparing the sub-dimensions addressing teachers' implementation of the standards-based mathematics curriculum, on the overall implementation of the organisation and structure of the curriculum (OSC) using 2 items, the results show teachers demonstrated a moderate implementation ($M = 4.06$; $SD = 1.83$). Apart from this, assessing the overall implementation of each remaining sub-dimension using 4 items, the results reveal that teachers demonstrated moderately high implementation of recommended assessment practices (RAP) ($M = 9.01$; $SD = 2.82$), followed by a moderate implementation of inclusion and equity pedagogy (IEP) ($M = 8.56$; $SD = 2.87$), a moderate implementation of differentiation and scaffolding pedagogy (DSP) ($M = 8.44$; $SD = 2.96$), and then a moderate implementation of learner-centred pedagogy (LCP) ($M = 8.22$; $SD = 2.86$). The remaining are for the moderate implementation of the core competencies (CC) ($M = 8.19$; $SD = 2.82$), the instructional expectations of the curriculum (IEC) ($M = 8.17$; $SD = 2.73$) and the expected learning behaviours (ELB) ($M = 8.07$; $SD = 2.64$). Among all the sub-dimensions, the results further show that teachers demonstrated a low implementation of ICT ($M = 5.55$; $SD = 2.75$). Overall, teachers' implementation of the standards-based mathematics curriculum was moderate ($M = 68.27$; $SD = 13.79$). Examining the skewness and kurtosis values, which both fall within ranges of ± 2 and ± 7 respectively, indicates that the data is normally distributed (Kline, 2016).

Regarding the results in Table 42, further follow-up interviews were done with the teachers to examine what could account for the low ICT implementation concerning the standards-based mathematics curriculum. The responses gathered were analysed thematically. Twenty-one (21) teachers'

interviews were taken into account due to the saturation of the data. Out of the 21 interviews done with the teachers in Basic 1 to Basic 6, 67 codes were generated. These codes were further grouped into 5 themes comprising inadequate ICT resources and tools, lack of administrative support, inadequate training and workshops on ICT, inadequate knowledge of ICT integration and inadequate trained ICT teachers to handle ICT. Below are the thematic presentations of these themes.

Inadequate ICT Resources and Tools

From the interviews, it was observed that teachers complained about the lack of ICT resources and tools such as computers, internet access, laboratories and electricity as one of the issues for low ICT implementation concerning the standards-based mathematics curriculum. Here are a couple of comments from the teachers.

“Please just look at the school what do we have? The whole thing pertains to the lack of ICT teachers, materials and laboratories” (Excerpt from Teacher 3).

“My brother, the problems are not far fetched. Is a lack of materials from the government. Teachers also do not receive enough training on the new curriculum” (Excerpt from Teacher 7).

“Implementation of any part of the curriculum, there must be enough education, proper planning and implementation strategy. Most schools lack the required materials to roll out the programmes. ICT tools are not readily available in most schools” (Excerpt from Teacher 8).

“I can talk about the lack of computers in the various schools. Most schools do not have computers, electricity or even ICT teachers to help the learners to learn. Some teachers lack confidence in teaching ICT, therefore making the low implementation of ICT” (Excerpt from Teacher 9).

“Many schools do not have the necessary resources such as computers, software and internet access to effectively integrate ICT into the mathematics curriculum. Also, teachers do not receive adequate training in how to effectively use ICT in the classroom or they do not have access to ongoing support and professional development

opportunities. And others too are not prepared to change” (Excerpt from Teacher 15).

“All I can say is inadequate ICT tools, availability of electricity is difficult in some areas, and some teachers have lower knowledge in terms of using the ICT tools” (Excerpt from Teacher 17).

“We have limited ICT devices in the school. The available ones are all not good. So, virtually we do not have ICT tools in the school” (Excerpt from Teacher 19).

“For the ICT issue, look through the whole school and check the number of ICT devices we have. How can we be effective with this small number of ICT devices? They are not sufficient for the lessons. Those available are not functioning properly. This is the problem we have” (Excerpt from Teacher 20).

The comments from the teachers seem to demonstrate that ICT resources and tools such as computers, internet access, and electricity in the various schools are some of the issues contributing to low ICT implementation regarding the standards-based mathematics curriculum. The teachers’ comments seem to imply that there are not enough computers and accessories in the various schools for smooth and effective ICT implementation.

Lack of Administrative Support

From the interviews, it was further observed that teachers complained about the lack of administrative support as one of the concerns for low ICT implementation regarding the standards-based mathematics curriculum implementation. Here are a couple of comments from the teachers.

“This is due to inadequate computers in the school. Also, inadequate time allocated, limited access to resources and lack of administrative support. Our headteachers are not helping us get enough computers but at times too you can not blame them entirely. You ask and they say there is no money in the school, in this case, what can you do”? (Excerpt from Teacher 4).

“I see it from limited access to resources, inadequate time allocated to mathematics and lack of administrative support. Headteachers are supposed to find means of getting computers in the school if the government is not bringing them. Are they doing it? The answer is no

that is why I am saying lack of administrative support” (Excerpt from Teacher 5).

“This is due to limited access to resources, inadequate time allocated to mathematics and lack of administrative support. Those authorities such as headteachers and the office who are to supply us with computers and other tools. These items are not forthcoming so what can we do for the ICT implementation? Authorities have many things to do by providing us with these accessories if not you will still go and come back to talk about the same issue” (Excerpt from Teacher 11).

“The low implementation of ICT is hindered due to limited access to resources, lack of computers and lack of quality software. I can also say inadequate time allocated to mathematics, lack of administrative support and teachers’ attitudes towards computers. I am relating it to assistance we need to get from headteachers and GES officers which is not the case. Headteachers complain about funds so we teachers what should we do? ICT is more practical and needs to be taught as such with computers” (Excerpt from Teacher 21).

The teachers’ remarks seem to suggest that the kind of support they receive from headteachers and officers at the Directorate is one of the issues contributing to low ICT implementation. The teachers’ comments seem to imply that they are not receiving the assistance they require from their superiors such as headteachers and officers at the Directorate to obtain computers and other ICT tools, which is a factor for low ICT implementation regarding the standards-based mathematics curriculum.

Inadequate Training and Workshops on ICT

From the interviews, it was observed that teachers complained about inadequate training and workshops on ICT as one of the issues for low ICT implementation regarding the standards-based mathematics curriculum implementation. Below are a couple of comments from the teachers.

“My brother, the problems are not far fetched. Is a lack of materials from the government. Teachers also do not receive enough training on the new curriculum” (Excerpt from Teacher 7).

“Many schools do not have the necessary resources such as computers, software and internet access to effectively integrate ICT into the mathematics curriculum. Also, teachers do not receive adequate

training in how to effectively use ICT in the classroom or they do not have access to ongoing support and professional development opportunities. And others too are not prepared to change” (Excerpt from Teacher 15).

“This is due to lack of training on the subject of ICT and the problem of no computers in the schools. Again, no electricity in the school does not facilitate the need to call for computers in the school” (Excerpt from Teacher 18).

The teachers’ comments seem to suggest that the kind of training they receive and the workshops they attend regarding the standards-based mathematics curriculum implementation are some of the issues contributing to low ICT implementation. Their comments seem to suggest that the training and workshops are not enough to enable them to effectively implement ICT.

Inadequate Knowledge of ICT Integration

From the interviews, it was observed that teachers complained about the inadequate knowledge of ICT integration as one of the concerns for low ICT implementation regarding the standards-based mathematics curriculum implementation. Here are a couple of comments from the teachers.

“I see it from multiple perspectives. Limited access to resources, inadequate time allocated to mathematics, lack of administrative support, and teachers’ negative attitudes towards ICT tools. Also, low or poor internal service during teaching and learning, projects and assignments. What teachers do in the classroom is it of quality? Are they able to apply the ICT in the teaching and learning process? I see it to be low or poor affecting the implementation” (Excerpt from Teacher 6).

“Lack of ICT devices is one factor that is accounting for the low implementation of ICT regarding the standards-based mathematics curriculum. Also, inadequate knowledge of ICT is another cause. I am talking about how teachers can integrate ICT into the teaching and learning process and that is the main challenge most teachers are confronted with” (Excerpt from Teacher 13).

“What I will say is lack of ICT tools and inadequate knowledge of ICT are accounting for the low implementation. I am referring to how teachers integrate ICT into the teaching process. I mean knowledge about ICT utilisation during teaching and this is what most teachers are lacking” (Excerpt from Teacher 14).

“All I can say is inadequate ICT tools, availability of electricity is difficult in some areas, and some teachers have lower knowledge in terms of using ICT tools. What I mean is teachers’ inability to integrate ICT into their teaching process. Most teachers find it difficult” (Excerpt from Teacher 17).

The teachers’ remarks seem to suggest that the kind of knowledge they possess on how to integrate ICT is one of the issues contributing to low ICT implementation. The teachers’ comments seem to imply that some of the teachers’ knowledge they possess to utilise ICT tools regarding the standards-based mathematics curriculum implementation is not enough.

Inadequate Trained ICT Teachers

From the interviews, it was noticed that teachers complained about the inadequately trained ICT teachers to handle ICT as one of the concerns for low ICT implementation concerning the standards-based mathematics curriculum. Here are a couple of comments from the teachers.

“Please just look at the school what do we have? The whole thing pertains to the lack of ICT teachers, materials and laboratories” (Excerpt from Teacher 3).

“I can talk about the lack of computers in the various schools. Most schools do not have computers, electricity or even ICT teachers to help the learners to learn. Some teachers lack confidence in teaching ICT, therefore making the low implementation of ICT” (Excerpt from Teacher 9).

“For me is how teachers deliver instruction and assessment. Also, lack of adequately trained teachers and negative attitudes among teachers” (Excerpt from Teacher 16).

The teachers’ comments seem to suggest that training ICT teachers to handle ICT in the various classrooms is one of the issues contributing to low ICT implementation. The teachers’ remarks seem to imply that the number of trained ICT teachers to handle ICT regarding the implementation of the standards-based mathematics curriculum is not enough. The results obtained for

the sub-dimensions addressing the teachers' implementation of the standards-based mathematics curriculum are further discussed.

Discussion of Results of Research Question 5

Overall, the teachers demonstrated a moderate implementation of the standards-based mathematics curriculum. The results appear to suggest that the teachers' delivery of the standards-based mathematics curriculum was average. As maintained by Rogan and Grayson (2003), teachers' practice of curriculum in the classroom is crucial. To them, teachers remain critical factors because successful curriculum implementation requires teachers' capacity to innovate and their classroom practices. Relating Rogan and Grayson's (2003) concept of "profile of implementation" to this study's findings, on average, it suggests that the teachers are putting into practice the demands of the standards-based mathematics curriculum.

Similarly, on "capacity to innovate" in terms of teachers' knowledge, on average, it implies that the teachers are demonstrating an appreciable level of knowledge about the implementation of the standards-based mathematics curriculum. However, this study's findings contradict Garcia and Rosa (2021), who reported teachers' high mathematics curriculum implementation regarding its content standards and other aspects of the curriculum. Also, contrary to this current study's finding, Rudhumbu and Rudhumbu (2018) reported teachers' low quality implementation of the primary school mathematics curriculum. Moreover, in contrast to this study's findings, Kabombwe and Mulenga (2019) revealed teachers' ineffective use of competency-based curriculum pedagogical approaches. The finding from this study implies that generally, the teachers'

implementation of the standards-based mathematics curriculum is somewhat appreciable.

Regarding teachers' implementation of the organisation and structure of the curriculum, overall, the teachers demonstrated a moderate implementation. This appears to suggest that the teachers exhibited a fair implementation of the organisation and structure of the standards-based mathematics curriculum. Contrary to this study's finding, Garcia and Rosa (2021) reported a high implementation of mathematics curriculum content standards by teachers. Further, this current study's finding revealed that the teachers demonstrated a moderate implementation of the strands, sub-strands, content standards, and indicators and also considered the curriculum's annotation. What this seems to suggest is that the teachers putting into practice the curriculum's strands, sub-strands, content standards, indicators and annotations were within average.

Concerning teachers' implementation of the expected learning behaviours of the standards-based mathematics curriculum, overall, the teachers demonstrated a moderate implementation. The results appear to suggest that generally, the teachers' implementation of the expected learning behaviours of the curriculum was average. The findings further reveal that the teachers exhibited a moderately high implementation of developing learners' skills in observing, classifying, comparing, communicating, reporting, predicting and interpreting. What this seems to suggest is that teachers' practice of developing learners' skills in observing, classifying, comparing, communicating, reporting, predicting and interpreting was generally average.

Similarly, it was found that the teachers' implementation of engaging learners to analyse, synthesise, evaluate and create was moderate. However, it

was found that the teachers demonstrated a low implementation of engaging learners in mathematics activities to develop their attitudes and values. What this seems to suggest is that most of the teachers were not fusing the development of attitudes and values during mathematics lessons. Consistent with this study's findings, Rupani and Bhutto (2011) reported that most teachers hardly touch affective learning domains during instruction. This could be that teachers probably do not see the connection between infusing attitudes and values while teaching and learning mathematics.

Pertaining to teachers' implementation of the instructional expectations of the standards-based mathematics curriculum, overall, the teachers' implementation was moderate. This finding appears to suggest that generally, the teachers exhibited an average implementation of the instructional expectations of the curriculum. Contrary to this study's finding, Pagana et al. (2015) revealed that teachers' practices in the classroom do not reflect the aims and objectives of the mathematics curriculum. Further, this current study's finding revealed that the teachers demonstrated a moderate implementation of making learners work together as colleagues and generating discourse among themselves in mathematics lessons. What this seems to suggest is that the teachers allow learners to work together as friends.

As emphasised by NaCCA (2019), teachers are to engage learners in such a way that learners work together as colleagues for them to become communities of mathematics learners who demonstrate mathematical inquiry skills. This implies that when teaching and learning the standards-based curriculum, learners are expected to partner with one another to explore mathematics concepts. It was discovered that the teachers demonstrate low

implementation of engaging learners to construct their own knowledge and understanding. This finding appears to suggest that most of the teachers were not allowing learners to come out with their own perspectives during mathematics lessons as recommended.

Concerning teachers' implementation of the core competencies of the standards-based mathematics curriculum, overall, the finding shows teachers' moderate implementation. This finding appears to suggest that largely, the teachers' practice of the core competencies was moderately fair. Consistent with this study's finding, Isaboke (2021) reported teachers' ability to practice core competencies of the competency-based curriculum. This current study's findings further revealed that the teachers demonstrated a moderately higher implementation of engaging learners actively to participate, communicate and collaborate in sharing their ideas in mathematics lessons. This finding appears to suggest that the teachers engage learners to participate actively, communicate and collaborate with friends during mathematics lessons. This current study's finding agrees with Isaboke (2021) who reported that 57 % of teachers trained on a competency-based curriculum (CBC) demonstrate a good ability to infuse communication and collaboration.

However, the current study's findings further show teachers' moderately lower implementation of engaging learners in problem-solving and problem-posing activities to develop their critical thinking skills. This finding seems to suggest that the teachers' engagement of learners in problem-solving and problem-posing to develop their critical thinking skills was slightly above average. This finding is consistent with Isaboke (2021) who reported that 50 %

of the trained teachers on a competency-based curriculum exhibit the ability to infuse critical thinking and problem-solving.

On teachers' implementation of the learner-centred pedagogy of the standards-based mathematics curriculum, overall, it was found that the teachers exhibited a moderate implementation. This finding seems to indicate that the teachers demonstrated an average implementation of the learner-centred pedagogy. This study's finding agrees with Khadka, Joshi, Adhikari and Khanal (2022) who reported teachers' use of learner-centred instruction for mathematics lessons. However, contrary to this current study's finding, Chibunn, Unamba and Olawuyi (2017) reported very few teachers utilising learner-centred pedagogy for implementing the mathematics curriculum. Further, analysing individual items addressing learner-centred pedagogy, the findings revealed that the teachers exhibited a moderately higher implementation of engaging learners in meaningful hands-on activities during mathematics lessons. This finding appears to suggest that most of the teachers engage learners in hands-on activities.

As maintained by NaCCA (2019), engaging learners in meaningful hands-on activities in the course of delivering the standards-based curriculum helps to consolidate learners' gains in the process of teaching and learning. It was noticed that the teachers' implementation of making learners take ownership of their learning in mathematics lessons to construct their knowledge was moderately low. What this seems to suggest is that the teachers appear to see themselves as dispensers of knowledge and regard learners as recipients of prepared information. As recommended, when implementing the standards-based mathematics curriculum, learners are to be put at the core of the teaching

and learning process to aid their construction of knowledge (MOE, 2019; NaCCA, 2019). What this implies is that learners' active engagement is key for delivering the standards-based mathematics curriculum.

Regarding teachers' implementation of inclusion and equity pedagogy of the standards-based mathematics curriculum, overall, it was found that the teachers' implementation was moderate. This finding appears to suggest that the teachers' implementation of inclusion and equity pedagogy for the standards-based mathematics curriculum was average. Contrary to this current study's finding, Deku and Vanderpuye (2017) reported teachers' lack of competence in teaching children in an inclusive classroom environment. Their report revealed that 55% of the teachers, which was more than average, admitted their lack of competence regarding utilising inclusive pedagogies in an inclusive classroom environment. This present study's findings show that teachers' use of inclusion and equity pedagogy is quite appreciable. Findings from this current study further reveal that the teachers demonstrated a moderately higher implementation of engaging learners through their learning experiences, needs, background and levels of motivation.

As recommended in the NPECF (2018), the delivery of the standards-based curriculum should be geared towards aligning teaching and learning to learners' needs, learning styles, learning experiences and motivational levels as a way of catering for each learner. This current study's findings appear to suggest that the teachers consider learners' different styles of learning, experiences and levels of motivation while delivering the standards-based mathematics curriculum. However, it was discovered that giving access to all learners during mathematics activities was the least moderately implemented.

This finding seems to suggest that most of the teachers were not giving access to all learners during mathematics activities. According to Florian (2014), instruction should be organised to benefit all students in the classroom. The current study's findings suggest that inclusion and equity pedagogy ought to be utilised effectively to benefit every learner.

On teachers' implementation of differentiation and scaffolding pedagogy, overall, it was found that the teachers' implementation was moderate. This finding appears to suggest that the teachers exhibited a fair implementation of differentiation and scaffolding pedagogy. The current study's finding contradicts Mengistie (2020) who reported teachers' low implementation of differentiated instruction. Also, contrary to this present study's findings, Ako, Osei, Asare and Amihere (2019) pointed out how teachers hardly apply differentiated instruction to satisfy learners' diverse needs. Moreover, in contradiction to this current study's findings, Mahharrini, Ansari and Yani (2020) revealed teachers' inability to utilise scaffolding pedagogy properly. Most of these studies seem to reveal teachers' low utilisation of differentiation and scaffolding pedagogy in the classroom.

However, the present study's findings point to teachers' moderate implementation. Further, it was found that the teachers exhibited a moderately high implementation of providing learners with mathematics vocabulary and exemplars and simplifying mathematics lessons. What this seems to suggest is that most of the teachers appear to offer learners mathematics vocabulary and exemplars during mathematics lessons. Further, it was found that the teachers demonstrated a low implementation of engaging learners with multiple ways to enhance their understanding. This finding seems to suggest that most of the

teachers hardly apply multiple ways to deepen learners' understanding. As recommended by NaCCA (2019), teachers are expected to deliver a standards-based curriculum to benefit every learner. The current study's finding implies that teachers ought to break down lesson content and apply different ways of engaging learners.

Regarding teachers' implementation of ICT, overall, it was found that the teachers demonstrated a low implementation. This finding appears to suggest that the teachers' utilisation of ICT regarding standards-based mathematics curriculum implementation was not encouraging. This seems to point out that most of the teachers barely use ICT during mathematics lessons. The current study's finding is consistent with Obielodan, Omojola, Tijani and Samuel (2020) who reported that teachers hardly utilise ICT tools for teaching. Similarly, Buabeng-Andoh (2019) reported that teachers rarely apply ICT in their teaching. These findings corroborate the current study's findings. However, the current study's finding contradicts Singh and Chan (2014) who reported teachers' sufficient use of ICT for teaching and learning.

Further, the present study's findings show that teachers demonstrated low implementation in using ICT to enhance learners' independence during mathematics lessons, access information, and organise mathematics activities to enhance learners' creativity. According to NTECF (2017), teachers are required to effectively and appropriately integrate ICT into the process of teaching and learning. What this suggests is that teachers are supposed to use ICT during lessons. It implies that in delivering the standards-based mathematics curriculum, ICT should be used prominently.

A follow-up interview analysis on what could account for teachers' low ICT implementation regarding the standards-based mathematics curriculum reveals that teachers attributed this phenomenon to inadequate ICT resources and tools, lack of administrative support, inadequate training and workshops on ICT, inadequate knowledge of ICT integration and inadequately trained ICT teachers to handle ICT. As maintained by Mishra and Koehler (2006), teachers need to be knowledgeable and skilful in integrating ICT during teaching and learning. In a similar view, Albirini (2006) believe that the higher the knowledge of teachers in technology, the more they may apply technology in the classroom. It thus suggests that teachers complaining of inadequate knowledge of ICT integration and inadequately trained ICT teachers to handle ICT accounting for low ICT implementation regarding the standards-based mathematics curriculum seem not to be far from reality.

Consistent with this current study's finding, Isaboke's (2021) study on teachers' ability to integrate core competencies such as digital literacy regarding competency-based curriculum (CBC) implementation revealed that 74% of the non-trained teachers on CBC need support to infuse digital literacy. It seems to suggest that naturally, when implementers are unable to receive enough training and attend workshops regularly on a new programme, they might be unable to adequately implement the programme. From this current study's findings, it thus suggests that teachers complaining of inadequate training and workshops on ICT accounting for low ICT implementation regarding the standards-based mathematics curriculum appear to be close to reality.

Concerning teachers' implementation of recommended assessment practices of the standards-based mathematics curriculum, the findings show

that, overall, teachers demonstrated a moderately higher implementation. This finding appears to suggest that the teachers' implementation of the recommended assessment practices in the curriculum was averagely high. Assessing individual items addressing teachers' implementation of the recommended assessment practices, it was found that teachers demonstrated a moderately high implementation of using feedback from learners' assessments to improve their learning. This finding seems to suggest that the teachers regularly utilise responses from learners' assessments to assist them in improving learning. As indicated by NaCCA (2019), classroom assessment is done to gather information about the learner as a way of informing teachers' decisions for improving and promoting the learning of learners.

It was discovered that teachers' assessment of learners' learning using their portfolios, project work, presentations, interviews and diaries was the least moderately implemented. This finding appears to suggest that teachers' use of authentic assessment practices as recommended in the standards-based mathematics curriculum was less appreciable. This finding agrees with Buddo (2015) who reported teachers' limited use of authentic means of assessing learners. The current study's findings show that teachers' use of learners' portfolios, project work, presentations, interviews and diaries for assessing them was less encouraging. As emphasised in the NPECF (2018), assessment under the standards-based curriculum should engage learners to learn, and teachers are to do this by engaging learners in authentic assessment methods such as learner observation, anecdotal records, interviews, portfolios and projects. What it implies is that teachers are to assess learners' learning by employing varied authentic assessment methods.

Comparing the various sub-dimensions addressing the standards-based mathematics curriculum implementation, it was found that teachers' implementation of recommended assessment practices was moderately higher compared with other sub-dimensions. This suggests that teachers utilise the recommended assessment practices more, followed by the implementation of inclusion and equity pedagogy, differentiation and scaffolding pedagogy and learner-centred pedagogy. The least moderately implemented aspect was ICT. The findings showed that teachers hardly employ ICT for delivering the standards-based mathematics curriculum.

Overall, teachers' implementation of the standards-based mathematics curriculum was found to be moderate. This finding seems to suggest that teachers demonstrated a fair implementation of the curriculum. This current study's finding contradicts Rudhumbu and Rudhumbu (2018) who reported teachers' low quality of implementation of the primary school mathematics curriculum with most teachers utilising teacher-centred pedagogies. Also, contrary to this current study's findings, it was found that the national standard-based curriculum implementation was not yet successful (Rusdiana & Nasihudin, 2018). This current study's finding seems to suggest that teachers' implementation of the standards-based mathematics curriculum was somewhat appreciable.

Test of Research Hypotheses (Null Hypotheses Testing)

In all four (4) null hypotheses were set to guide this study. Before addressing each null hypothesis, an initial test of normality was done for each variable. In addressing the test of normality, skewness, kurtosis, mean, 5% trimmed mean and median values were used. Further, histograms with

normality curves and normal Q-Q plots were visually checked to assess the test of normality. The results for skewness, kurtosis, mean, 5% trimmed mean and median values are presented in Table 43, while histograms with normality curves and normal Q-Q plots are displayed in Figure 12.

Table 43: Test of Normality Using Skewness, Kurtosis, Mean, 5% Trimmed Mean and Median Values

Variable	M	5% Trimmed Mean	Median	Skewness Statistic	SE	Kurtosis Statistic	SE
CK	9.89	9.88	10.00	.012	.086	-.030	.172
PK	10.03	10.06	10.00	-.135	.086	-.039	.172
PCK	4.88	4.89	5.00	-.070	.086	-.354	.172
CtK	4.73	4.74	5.00	-.150	.086	-.011	.172
Imple. Scores	68.27	68.54	70.00	-.291	.086	.858	.172
Students' Average Performance Scores	10.43	10.40	10.00	.094	.086	-.105	.172

Source: Fieldwork, 2023; N = 803; M = Mean; SE = Std. Error; content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), contextual knowledge (CtK)

From Table 43, an inspection of the skewness and kurtosis values for CK, PK, PCK, CtK, implementation scores and students' average performance scores shows that, for each variable, skewness and kurtosis values fall within the acceptable range of ± 2 and ± 7 respectively (Kline, 2016). Hence, the data for each variable could be described as approximately normally distributed. Further, inspecting the mean, 5% trimmed mean, and median values shows that, for each variable, the mean, 5% trimmed mean, and median values are almost the same, implying that the data for each variable is approximately normally distributed (Gravetter & Wallnau, 2014). Additionally, Figure 12 displays histograms with normality curves and normal Q-Q plots for the data.

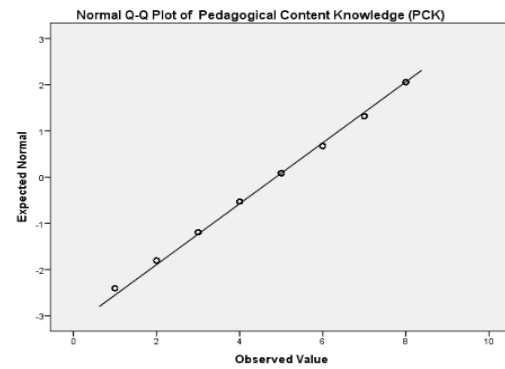
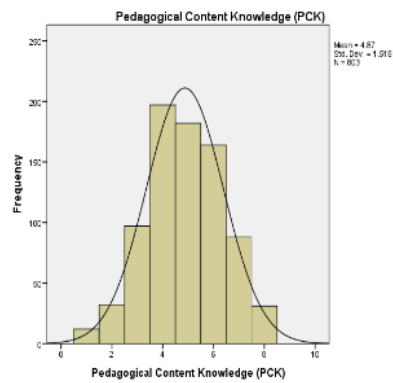
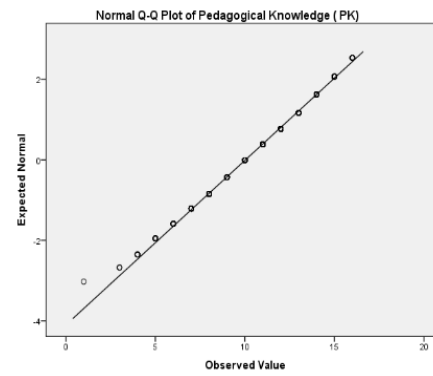
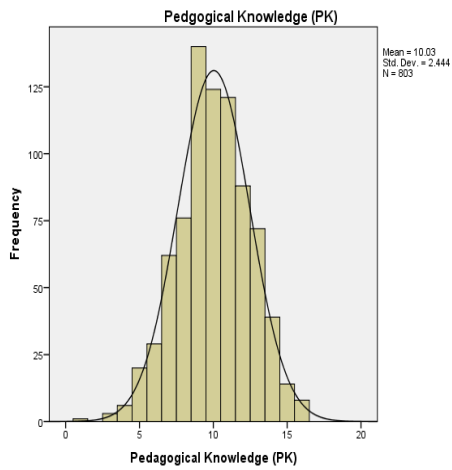
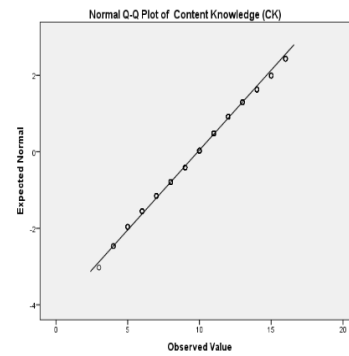
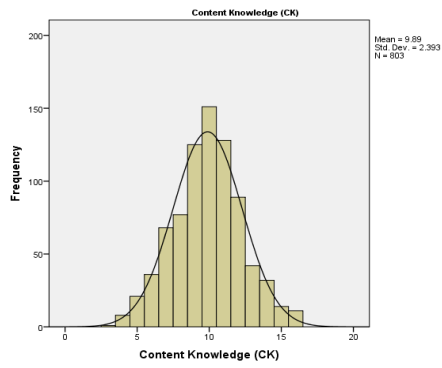


Figure 12: Testing Normality of the Data Using Histogram with Normality Curve and Normal Q-Q Plot
Source: Fieldwork, 2023

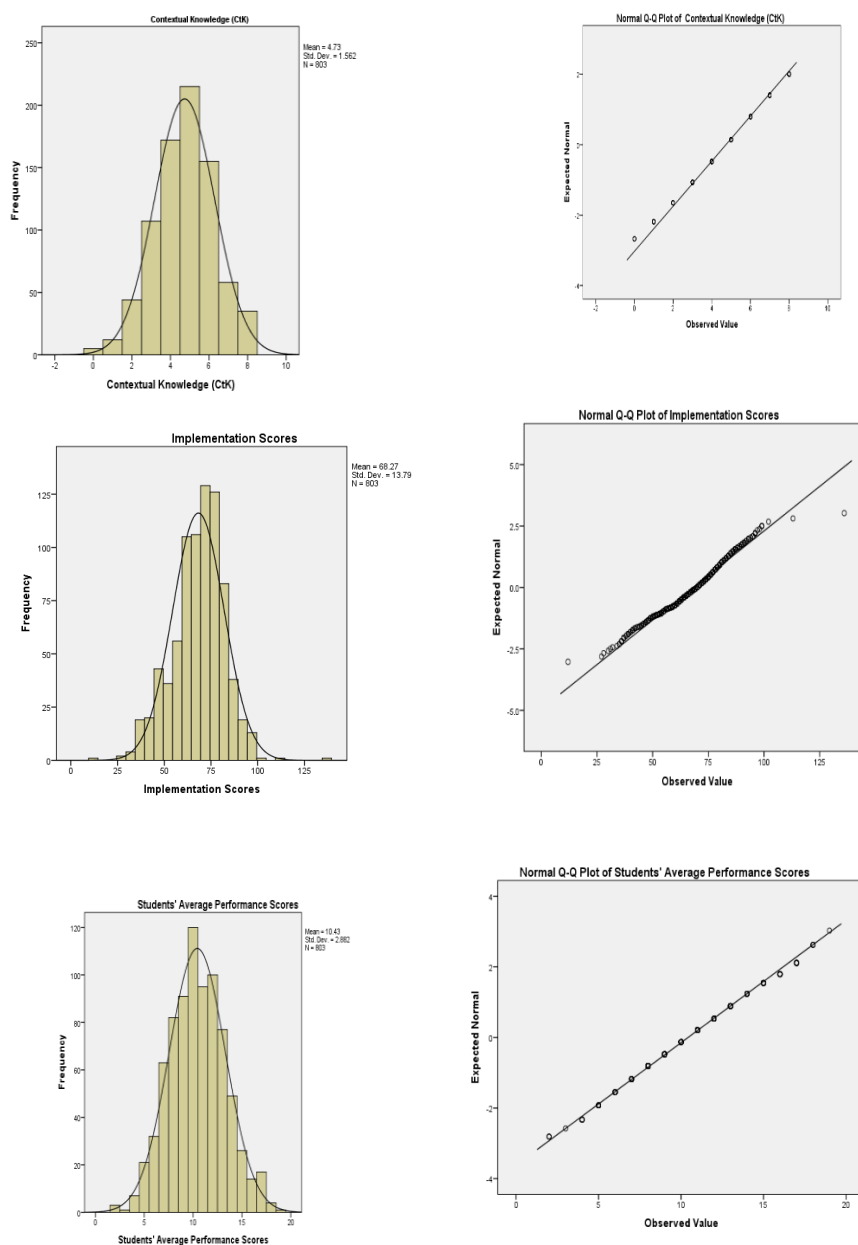


Figure 12, continued.

Source: Fieldwork, 2023

From Figure 12, for CK data, it is noticed that the normality curve for the histogram assumes a bell shape and for the normal Q-Q plot, nearly all the points are located on the diagonal line. Hence, the data for CK could be described as fairly normally distributed (Das & Imon, 2016; Oppong & Agbedra, 2016). For PK data, similarly, it is noticed that the histogram's normality curve is bell-shaped and for the normal Q-Q plot, almost all the points

are found on the diagonal line. Therefore, PK data could be considered as approximately normally distributed (Das & Imon, 2016; Oppong & Agbedra, 2016). In the case of PCK data, the histogram's normality curve takes on a bell-shaped form and almost every point on the normal Q-Q plot is situated on the diagonal line making the data fairly normally distributed (Das & Imon, 2016; Oppong & Agbedra, 2016). For CtK data, the normality curve of the histogram is observed to take on a bell-shaped form and nearly each point on the normal Q-Q plot is situated on the diagonal line. Therefore, CtK data could be said to be reasonably normally distributed. Observing the histogram for the implementation scores, the normality curve assumes a bell shape and almost all the points on the normal Q-Q plot lie on the diagonal line. Therefore, the data could be described as not deviating from normality. Looking at the histogram for the students' average performance scores, the normality curve depicts a bell shape and nearly all of the points on the normal Q-Q plot are located on the diagonal line giving the plot a linear pattern. Therefore, data for students' average performance scores could be described as approximately normally distributed (Das & Imon, 2016; Oppong & Agbedra, 2016).

Looking at the skewness, kurtosis, mean, 5% trimmed mean and median values and further inspection of the normality curve of the histograms and the normal Q-Q plots for each data, it could be concluded that the various data are approximately normally distributed. Hence, the various data are suitable for the parametric test analysis.

Some scholars (Pallant, 2007; Schmidt & Finan, 2018; Tsagris, Alenazi, Verrou & Pandis, 2020) still argue that when you have a large size sample (in my case $n = 803$) and you violate the normality assumption, it should not result

in a serious issue for your test. It implies that parametric test analysis could be applied in cases where the data are not normally distributed (Elliott & Woodward, 2007). Therefore, data for CK, PK, PCK, CtK, implementation scores and students' average performance are considered suitable for conducting the parametric test analyses.

Research Hypothesis One (Ho₁): There is no significant difference in teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum across their academic qualifications, mode of certificate acquisition and grade levels, controlling for the effects of years of experience in teaching, age and gender.

This research hypothesis sought to examine whether a statistically significant difference exists in teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum across their academic qualifications, mode of certificate acquisition and grade levels when the effects of their years of experience in teaching, age and gender are controlled for. A One-Way MANCOVA was used for analysing this data through SPSS versions 22 and 27. Teachers' content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK) and contextual knowledge (CtK) were entered as continuous dependent variables, teachers' academic qualifications, mode of certificate acquisition and grade levels were keyed as independent variables and teachers' years of experience in teaching, age and gender were entered as controlling variables (covariates) in the SPSS.

Separate analyses of One-Way MANCOVA were done for each independent variable to examine statistical differences if any in teachers' CK, PK, PCK and CtK when their years of experience in teaching, age and gender are controlled for. Initial correlations among the controlling variables (covariates) were checked. Also, correlations among the continuous dependent variables were assessed. The results obtained are presented in Tables 44 and 45 respectively.

Table 44: Correlation Among the Controlling Variables (Covariates)

	Gender	Years of teaching experience	Age
Gender			
Years of teaching experience	-.062		
Sig. (2-tailed)	.078		
Age	.004	.902**	
Sig. (2-tailed)	.901	.000	

Source: Fieldwork, 2023; N = 803, **. Correlation is significant at the .01 level (2-tailed) (** $p < .01$)

From Table 44, the Pearson correlation (r) and point biserial correlation (r_{pb}) results were interpreted using the Schober, Boer and Schwarte (2018) suggested cut-off benchmark. Correlation coefficient (r) values ranging from 0.00 to 0.09 (0.00 to -0.09) were considered “negligible correlation”, 0.10 to 0.39 (-0.10 to -0.39) were regarded as “weak positive or weak negative correlation”, 0.40 to 0.69 (-0.40 to -0.69) were described as “moderate positive or moderate negative correlation”, 0.70 to 0.89 (-0.70 to -0.89) were considered “strong positive or strong negative correlation”, and 0.90 to 1.00 (-0.90 to -1.00) were interpreted as “very strong positive or very strong negative correlation”. The results show that no significant relationship was found between teachers' gender and years of teaching experience [r_{pb} (801) = -.06; p = .07 (2-tailed)], between teachers' gender and age [r_{pb} (801) = .00; p = .90 (2-tailed)]. A very

strong relationship was found between teachers' age and years of teaching experience [$r(801) = .90; p < .001$ (2-tailed)]. Since age and years of teaching experience were found to be correlated strongly, age was not included as a covariate in the analysis. Consistent with many scholars' views (Chavent, Lacaille, Mourer & Olteanu, 2021; Chowdhury & Turin, 2020; Freckleton, 2011), when two variables are correlated strongly, it is prudent to consider removing one of such variables. They maintain that this should not impact the analysis. Table 45 presents the results of the correlation among the dependent variables.

Table 45: Correlation Among the Dependent Variables

	CK	PK	PCK	CtK
CK				
PK	.388**			
PCK	.096**	.266**		
CtK	.138**	.196**	.309**	

Source: Fieldwork, 2023; N = 803, **. Correlation is significant at the .01 level (2-tailed) (** $p < .01$)

As indicated by Tabachnick and Fidell (2012), when performing MANCOVA analysis, the correlations between dependent variables should not be too strong. Looking at the Pearson correlation results between the continuous dependent variables from Table 45, it was observed that the correlation between teachers' CK and PK [$r(801) = .38; p < .001$ (2-tailed)] was not too strong. Between teachers' CK and PCK [$r(801) = .09; p < .001$ (2-tailed)] was not strong. Similarly, the correlation obtained between teachers' CK and CtK [$r(801) = .13; p < .001$ (2-tailed)] was not strong. The correlation found between teachers' PK and PCK was not strong [$r(801) = .26; p < .001$ (2-tailed)]. Between teachers' PK and CtK [$r(801) = .19; p < .001$ (2-tailed)], the correlation found was not strong. Again, the correlation between teachers' PCK

and CtK [$r(801) = .30$; $p < .001$ (2-tailed)] was not strong. Therefore, all the continuous dependent variables were included in the analysis.

Firstly, One-Way MANCOVA was performed to examine whether teachers' CK, PK, PCK and CtK about the standards-based mathematics curriculum differ across their academic qualifications when years of teaching experience and gender were controlled for. An initial test of homogeneity of regression was carried out to assess the interactions between the covariates (years of teaching experience and gender) and the independent variable (academic qualification) across the dependent variables (CK, PK, PCK and CtK). The results obtained are displayed in Table 46.

Table 46: Test of Homogeneity of Regression for Academic Qualification, Gender and Teaching Experience Across the Dependent Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	CK	128.568 ^a	11	11.688	2.071	.020
	PK	108.052 ^b	11	9.823	1.659	.078
	PCK	31.310 ^c	11	2.846	1.240	.256
	CtK	46.376 ^d	11	4.216	1.745	.060
Intercept	CK	667.284	1	667.284	118.236	.000
	PK	939.139	1	939.139	158.594	.000
	PCK	179.523	1	179.523	78.207	.000
	CtK	141.807	1	141.807	58.695	.000
Academic Qualification	CK	52.390	3	17.463	3.094	.026
	PK	10.239	3	3.413	.576	.631
	PCK	1.811	3	.604	.263	.852
	CtK	4.483	3	1.494	.618	.603
Gender	CK	1.568	1	1.568	.278	.598
	PK	16.378	1	16.378	2.766	.097
	PCK	8.924	1	8.924	3.888	.049
	CtK	12.620	1	12.620	5.224	.023
Teaching Experience	CK	.162	1	.162	.029	.865
	PK	4.279	1	4.279	.723	.396
	PCK	.305	1	.305	.133	.716
	CtK	1.045	1	1.045	.432	.511
Academic Qualification * Gender	CK	3.991	3	1.330	.236	.871
	PK	20.592	3	6.864	1.159	.324
	PCK	4.826	3	1.609	.701	.552
	CtK	7.015	3	2.338	.968	.407
Academic Qualification * Teaching Experience	CK	50.175	3	16.725	2.963	.031
	PK	5.705	3	1.902	.321	.810
	PCK	5.112	3	1.704	.742	.527
	CtK	7.469	3	2.490	1.030	.378

Table 46, Continued

Error	CK	4464.119	791	5.644
	PK	4684.040	791	5.922
	PCK	1815.734	791	2.295
	CtK	1911.058	791	2.416
Total	CK	83083.000	803	
	PK	85633.000	803	
	PCK	20915.000	803	
	CtK	19940.000	803	
Corrected Total	CK	4592.687	802	
	PK	4792.092	802	
	PCK	1847.044	802	
	CtK	1957.435	802	

Source: Fieldwork, 2023; a. R Squared = .028 (Adjusted R Squared = .014); b. R Squared = .023 (Adjusted R Squared = .009); c. R Squared = .017 (Adjusted R Squared = .003); d. R Squared = .024 (Adjusted R Squared = .010); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

From Table 46, the results of the test of homogeneity of regression show that there were no significant interactions between academic qualifications and gender (academic qualification * gender) for CK [$F(3, 791) = .23; p = .87$]; PK [$F(3, 791) = 1.15; p = .32$]; PCK [$F(3, 791) = .70; p = .55$] and CtK [$F(3, 791) = .96; p = .40$]. Further, the results indicate that the interactions between academic qualifications and teaching experience (academic qualification * teaching experience) were not significant for PK [$F(3, 791) = .32; p = .81$]; PCK [$F(3, 791) = .74; p = .52$]; CtK [$F(3, 791) = 1.03; p = .37$], except for CK [$F(3, 791) = 2.96; p = .03$]. The results show that the interaction between the independent variable (academic qualification) and covariates (gender and teaching experience) is insignificant, indicating no violations of the homogeneity of regression assumption.

The results of the “Box’s test of equality of covariance matrices” were also checked to assess whether the “covariance matrices” of the continuous dependent variables (CK, PK, PCK and CtK) are equal across the independent

variable (academic qualification). The results obtained are presented in Table 47.

Table 47: Box's Test of Equality of Covariance Matrices of the Dependent Variables Across Academic Qualification

	Box's M	F	df1	df2	Sig.
Value	37.595	1.130	30	3576.882	.285

Source: Fieldwork, 2023

The result of the Box's test in Table 47 is insignificant [Box's M = 37.595; $F(30, 3576) = 1.13$; $p = .28$]. This indicates that the “covariance matrices” of the dependent variables (CK, PK, PCK and CtK) are equal across the independent variable (academic qualifications). Hence, this assumption is also met. Again, “Levene's Test of equality of error variance was inspected to ascertain whether the variance of the dependent variables (CK, PK, PCK and CtK) is equal across the independent variable (academic qualification). The results generated are presented in Table 48.

Table 48: Levene's Test of Equality of Error Variances of the Dependent Variables Across Academic Qualification

	F	df1	df2	Sig.
CK	.396	3	799	.756
PK	1.865	3	799	.134
PCK	1.923	3	799	.124
CtK	.252	3	799	.860

Source: Fieldwork, 2023

From Table 48, the results of “Levene's test of equality of error variance further reveal that there are equal variances of the dependent variables, CK [$F(3, 799) = .39$; $p = .75$]; PK [$F(3, 799) = 1.86$; $p = .13$]; PCK [$F(3, 799) = 1.92$; $p = .12$]; CtK [$F(3, 799) = .25$; $p = .86$] across the independent variable (academic qualification). This shows no violation of this assumption. Satisfying

these assumptions, the results of One-Way MANCOVA were then generated.

The results obtained are presented in Table 49.

Table 49: One-Way MANCOVA Results for Teachers' Knowledge Across Their Academic Qualification, Gender and Teaching Experience

Effect		Value	F	Hypot thesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.719	508.235 ^b	4.000	794.000	.000	.719
	Wilks' Lambda	.281	508.235 ^b	4.000	794.000	.000	.719
	Hotelling's Trace	2.560	508.235 ^b	4.000	794.000	.000	.719
	Roy's Largest Root	2.560	508.235 ^b	4.000	794.000	.000	.719
	Pillai's Trace	.021	4.287 ^b	4.000	794.000	.002	.021
Gender	Wilks' Lambda	.979	4.287 ^b	4.000	794.000	.002	.021
	Hotelling's Trace	.022	4.287 ^b	4.000	794.000	.002	.021
	Roy's Largest Root	.022	4.287 ^b	4.000	794.000	.002	.021
	Pillai's Trace	.011	2.176 ^b	4.000	794.000	.070	.011
	Wilks' Lambda	.989	2.176 ^b	4.000	794.000	.070	.011
Teaching Experience	Hotelling's Trace	.011	2.176 ^b	4.000	794.000	.070	.011
	Roy's Largest Root	.011	2.176 ^b	4.000	794.000	.070	.011
	Pillai's Trace	.013	.837	12.000	2388.000	.612	.004
	Wilks' Lambda	.987	.838	12.000	2101.018	.611	.004
	Hotelling's Trace	.013	.838	12.000	2378.000	.611	.004
Academic Qualification	Roy's Largest Root	.011	2.204 ^c	4.000	796.000	.067	.011

Source: Fieldwork, 2023; b. Exact statistic

From Table 49, the multivariate test results show that the effect of gender as a covariate was statistically significant [Wilks' Lambda, $\Lambda_w = .979$; $F(4, 794) = 4.28$; $p = .002$; partial $\eta^2 = .021$] explaining 2.1% of the variance in teachers' knowledge. Using Cohen's (1988) benchmark for interpreting partial η^2 ; partial $\eta^2 < .01$ was considered a "negligible effect size", $.01 \leq \text{partial } \eta^2 < .06$ was regarded as a "small effect size", $.06 \leq \text{partial } \eta^2 < .14$ was considered a "medium effect size" and partial $\eta^2 \geq .14$ was described as a "large effect size".

Therefore, teachers' gender explained a small amount of variance (2.1%) in their knowledge. However, the effect of years of teaching experience as a covariate was statistically insignificant, $\Lambda_w = .989$; $F(4, 794) = 2.17$; $p = .07$; partial $\eta^2 = .011$, accounting for a small amount of variance (1.1%) in teachers' knowledge. Overall, the One-Way MANCOVA results show no statistically significant difference in teachers' knowledge across their academic qualification, $\Lambda_w = .987$; $F(12, 2101) = .83$; $p = .61$; partial $\eta^2 = .004$, when the effects of their gender and years of teaching experience were controlled for. The amount of variance (0.4%) in teachers' knowledge of the curriculum due to their academic qualifications was negligible. Further, the tests of between-subjects effects were examined. The results obtained are displayed in Table 50.

Table 50: Tests of Between-Subjects Effects on Teachers' Knowledge Across Their Academic Qualification, Gender and Teaching Experience

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	CK	62.706 ^a	5	12.541	2.206	.052	.014
	PK	79.606 ^b	5	15.921	2.693	.020	.017
	PCK	24.259 ^c	5	4.852	2.121	.061	.013
	CtK	35.561 ^d	5	7.112	2.949	.012	.018
Intercept	CK	6130.150	1	6130.150	1078.532	.000	.575
	PK	6578.073	1	6578.073	1112.518	.000	.583
	PCK	1500.105	1	1500.105	655.911	.000	.451
	CtK	1295.979	1	1295.979	537.442	.000	.403
Gender	CK	39.942	1	39.942	7.027	.008	.009
	PK	43.816	1	43.816	7.410	.007	.009
	PCK	16.932	1	16.932	7.404	.007	.009
	CtK	16.325	1	16.325	6.770	.009	.008
Teaching Experience	CK	15.264	1	15.264	2.685	.102	.003
	PK	29.195	1	29.195	4.938	.027	.006
	PCK	8.430	1	8.430	3.686	.055	.005
	CtK	8.019	1	8.019	3.326	.069	.004
Academic Qualification	CK	8.730	3	2.910	.512	.674	.002
	PK	11.218	3	3.739	.632	.594	.002
	PCK	.799	3	.266	.117	.950	.000
	CtK	13.609	3	4.536	1.881	.131	.007
Error	CK	4529.982	797	5.684			
	PK	4712.486	797	5.913			
	PCK	1822.784	797	2.287			
	CtK	1921.874	797	2.411			

Table 50, continued

Total	CK	83083.000	803
	PK	85633.000	803
	PCK	20915.000	803
	CtK	19940.000	803
Corrected Total	CK	4592.687	802
	PK	4792.092	802
	PCK	1847.044	802
	CtK	1957.435	802

Source: Fieldwork, 2023; a. R Squared = .014 (Adjusted R Squared = .007; b. R Squared = .017 (Adjusted R Squared = .010); c. R Squared = .013 (Adjusted R Squared = .007); d. R Squared = .018 (Adjusted R Squared = .012); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

From Table 50, before assessing the significance level of gender, years of teaching experience and academic qualifications across each dependent variable, Tabachnick and Fidell (2001) maintain that when dealing with many dependent variables, it is advisable to set a higher significance level to avoid “type I error”. In achieving this, you divide .05 by the number of dependent variables in your analysis. The value you obtain becomes the level you assess the significance. In my case, I divided .05 by 4 (i.e. $.05/4 = .01$) since I have 4 dependent variables. Therefore, for the test of between-subjects effects, the significance level was assessed at .01.

The test of between-subject effects results show that a statistically significant difference exists in teachers’ knowledge regarding CK, $F(1, 797) = 7.02$; $p = .008$; partial $\eta^2 = .009$; PK, $F(1, 797) = 7.41$; $p = .007$; partial $\eta^2 = .009$; PCK, $F(1, 797) = 7.40$; $p = .007$; partial $\eta^2 = .009$; and CtK, $F(1, 797) = 6.77$; $p = .009$; partial $\eta^2 = .008$ across gender. The amount of variances (0.9%; 0.8%) explained in each dependent variable was negligible. No statistically significant differences were found in teachers’ knowledge of CK, $F(1, 797) = 2.68$; $p = .10$; partial $\eta^2 = .003$; PK, $F(1, 797) = 4.93$; $p = .02$; partial $\eta^2 = .006$; PCK, $F(1, 797) = 3.68$; $p = .05$; partial $\eta^2 = .005$; and CtK, $F(1, 797) = 3.32$; p

=.06; partial η^2 =.004 across their years of teaching experience. A negligible amount of variance (0.3%; 0.6%; 0.5%; and 0.4% respectively) was explained in each dependent variable. Similarly, the results indicate no statistically significant difference in teachers' knowledge of CK, $F(3, 797) = .51$; $p = .67$; partial η^2 = .002; PK, $F(3, 797) = .63$; $p = .59$; partial η^2 = .002; PCK, $F(3, 797) = .11$; $p = .95$; partial η^2 = .000; and CtK, $F(3, 797) = 1.88$; $p = .13$; partial η^2 =.007 across their academic qualifications. In each dependent variable, the amount of variance explained (0.2%, 0.2%, 0.0%, and 0.7%, respectively) was negligible. This result suggests that teachers' knowledge of the curriculum does not differ significantly across their academic qualifications when the effects of gender and years of teaching experience are controlled for.

Secondly, One-Way MANCOVA was conducted to examine whether teachers' CK, PK, PCK and CtK about the standards-based mathematics curriculum differ across their mode of certificate acquisition when years of teaching experience and gender were controlled for. An initial test of homogeneity of regression was performed to assess the interactions between the covariates (years of teaching experience and gender) and the independent variable (mode of certificate acquisition) across the dependent variables (CK, PK, PCK and CtK). The results obtained are presented in Table 51.

Table 51: Test of Homogeneity of Regression for Mode of Certificate Acquisition, Gender and Teaching Experience Across the Dependent Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	CK	99.392 ^a	8	12.424	2.195	.026
	PK	101.332 ^b	8	12.666	2.144	.030
	PCK	31.291 ^c	8	3.911	1.710	.092
	CtK	36.436 ^d	8	4.554	1.882	.060
Intercept	CK	16642.409	1	16642.409	2940.842	.000

Table 51, Continued

	PK	17618.533	1	17618.533	2982.270	.000
	PCK	4111.106	1	4111.106	1797.722	.000
	CtK	3879.587	1	3879.587	1603.536	.000
Certificate Acquisition Mode	CK	21.098	2	10.549	1.864	.156
	PK	12.959	2	6.479	1.097	.334
	PCK	5.516	2	2.758	1.206	.300
	CtK	3.559	2	1.780	.736	.480
Gender	CK	29.087	1	29.087	5.140	.024
	PK	48.011	1	48.011	8.127	.004
	PCK	13.790	1	13.790	6.030	.014
	CtK	10.610	1	10.610	4.385	.037
Teaching Experience	CK	17.034	1	17.034	3.010	.083
	PK	26.019	1	26.019	4.404	.036
	PCK	4.370	1	4.370	1.911	.167
	CtK	7.564	1	7.564	3.126	.077
Certificate Acquisition Mode * Gender	CK	23.208	2	11.604	2.051	.129
	PK	16.229	2	8.115	1.374	.254
	PCK	3.284	2	1.642	.718	.488
	CtK	5.502	2	2.751	1.137	.321
Certificate Acquisition Mode * Teaching Experience	CK	16.118	2	8.059	1.424	.241
	PK	.828	2	.414	.070	.932
	PCK	2.997	2	1.499	.655	.520
	CtK	.143	2	.072	.030	.971
Error	CK	4493.296	794	5.659		
	PK	4690.761	794	5.908		
	PCK	1815.753	794	2.287		
	CtK	1920.999	794	2.419		
Total	CK	83083.000	803			
	PK	85633.000	803			
	PCK	20915.000	803			
	CtK	19940.000	803			
Corrected Total	CK	4592.687	802			
	PK	4792.092	802			
	PCK	1847.044	802			
	CtK	1957.435	802			

Source: Fieldwork, 2023; a. R Squared = .022 (Adjusted R Squared = .012); b. R Squared = .021 (Adjusted R Squared = .011); c. R Squared = .017 (Adjusted R Squared = .007); d. R Squared = .019 (Adjusted R Squared = .009); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

From Table 51, the results of the test of homogeneity of regression indicate that there were no significant interactions between the mode of certificate acquisition and gender (certificate acquisition Mode * gender) for CK [$F(2, 794) = 2.05; p = .12$]; PK [$F(2, 794) = 1.37; p = .25$]; PCK [$F(2, 794) = .71; p = .48$] and CtK [$F(2, 794) = 1.13; p = .32$]. The results also show

that the interactions between the mode of certificate acquisition and teaching experience (certificate acquisition mode * teaching experience) were not significant for CK [$F(2, 794) = 1.42; p = .24$]; PK [$F(2, 794) = .07; p = .93$]; PCK [$F(2, 794) = .65; p = .52$] and CtK [$F(2, 794) = .03; p = .97$]. The results demonstrate that the independent variable (mode of certificate acquisition) and covariates (gender and teaching experience) have no significant interaction, pointing to no violations of the homogeneity of regression assumption.

Additionally, the results of the “Box’s test of equality of covariance matrices” were examined to assess whether the “covariance matrices” of the continuous dependent variables (CK, PK, PCK and CtK) are equal across the independent variable (mode of certificate acquisition). The results obtained are presented in Table 52.

Table 52: Box's Test of Equality of Covariance Matrices of the Dependent Variables Across Mode of Certificate Acquisition

	Box's M	F	df1	df2	Sig.
Value	25.849	1.282	20	1392779.729	.178

Source: Fieldwork, 2023

The result of the Box’s test in Table 52 is insignificant [Box's M = 25.849; $F(20, 1392779) = 1.28; p = .17$]. This indicates that the “covariance matrices” of the dependent variables (CK, PK, PCK and CtK) are equal across the independent variable (mode of certificate acquisition). Hence, this assumption is met. The “Levene’s Test of equality of error variance was inspected to ascertain whether the variance of the dependent variables (CK, PK, PCK and CtK) is equal across the independent variable (mode of certificate acquisition). The results obtained are displayed in Table 53.

Table 53: Levene's Test of Equality of Error Variances of the Dependent Variables Across Mode of Certificate Acquisition

	F	df1	df2	Sig.
CK	.857	2	800	.425
PK	4.625	2	800	.010
PCK	2.336	2	800	.097
CtK	.548	2	800	.579

Source: Fieldwork, 2023

From Table 53, the results of “Levene’s test of equality of error variance further reveal that there are equal variances of CK, [$F(2, 800) = .85; p = .42$]; PCK, [$F(2, 800) = 2.33; p = .09$] and CtK, [$F(2, 800) = .54; p = .57$] across the independent variable (mode of certificate acquisition) except for PK, [$F(2, 800) = 4.62; p = .01$]. This shows no violation of this assumption. Meeting these assumptions, the results of One-Way MANCOVA were then generated. The results obtained are displayed in Table 54.

Table 54: One-Way MANCOVA Results for Teachers’ Knowledge Across Their Mode of Certificate Acquisition, Gender and Teaching Experience

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.887	1565.068 ^b	4.000	795.000	.000	.887
	Wilks' Lambda	.113	1565.068 ^b	4.000	795.000	.000	.887
	Hotelling's Trace	7.875	1565.068 ^b	4.000	795.000	.000	.887
	Roy's Largest Root	7.875	1565.068 ^b	4.000	795.000	.000	.887
Gender	Pillai's Trace	.020	4.074 ^b	4.000	795.000	.003	.020
	Wilks' Lambda	.980	4.074 ^b	4.000	795.000	.003	.020
	Hotelling's Trace	.020	4.074 ^b	4.000	795.000	.003	.020
	Roy's Largest Root	.020	4.074 ^b	4.000	795.000	.003	.020
Teaching Experience	Pillai's Trace	.011	2.207 ^b	4.000	795.000	.067	.011
	Wilks' Lambda	.989	2.207 ^b	4.000	795.000	.067	.011

Table 54, Continued

Certificate Acquisition Mode	Hotelling's Trace	.011	2.207 ^b	4.000	795.000	.067	.011
	Roy's Largest Root	.011	2.207 ^b	4.000	795.000	.067	.011
	Pillai's Trace	.014	1.448	8.000	1592.000	.172	.007
	Wilks' Lambda	.986	1.450 ^b	8.000	1590.000	.171	.007
	Hotelling's Trace	.015	1.453	8.000	1588.000	.170	.007
	Roy's Largest Root	.014	2.767 ^c	4.000	796.000	.026	.014

Source: Fieldwork, 2023; b. Exact statistic

From Table 54, the results of the multivariate test demonstrate that the effect of gender as a covariate was statistically significant, [Wilks' Lambda, $\Lambda_w = .980$; $F(4, 795) = 4.07$; $p = .003$; partial $\eta^2 = .020$] accounting for 2.0% of the variance in teachers' knowledge. Per Cohen's (1988) criteria, teachers' gender explained a small amount of variance (2.0%) in their knowledge. However, the effect of years of experience in teaching as a covariate was statistically insignificant, $\Lambda_w = .989$; $F(4, 795) = 2.20$; $p = .06$; partial $\eta^2 = .011$, accounting for a small amount of variance (1.1%) in teachers' knowledge. Overall, the One-Way MANCOVA results show no statistically significant difference in teachers' knowledge across their mode of certificate acquisition, $\Lambda_w = .986$; $F(8, 1590) = 1.45$; $p = .17$; partial $\eta^2 = .007$, when the effects of their gender and years of teaching experience were controlled for. The amount of variance (0.7%) in teachers' knowledge of the curriculum due to their mode of certificate acquisition was negligible. Further, the tests of between-subjects effects were examined. The results obtained are displayed in Table 55.

Table 55: Tests of Between-Subjects Effects on Teachers' Knowledge Across Their Mode of Certificate Acquisition, Gender and Teaching Experience

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	CK	62.584 ^a	4	15.646	2.756	.027	.014
	PK	83.850 ^b	4	20.963	3.553	.007	.017
	PCK	24.844 ^c	4	6.211	2.720	.029	.013
	CtK	30.629 ^d	4	7.657	3.171	.013	.016
Intercept	CK	18540.980	1	18540.980	3266.085	.000	.804
	PK	19635.274	1	19635.274	3327.983	.000	.807
	PCK	4649.879	1	4649.879	2036.332	.000	.718
	CtK	4363.132	1	4363.132	1807.022	.000	.694
Gender	CK	39.983	1	39.983	7.043	.008	.009
	PK	43.342	1	43.342	7.346	.007	.009
	PCK	16.436	1	16.436	7.198	.007	.009
	CtK	13.437	1	13.437	5.565	.019	.007
Teaching Experience	CK	15.556	1	15.556	2.740	.098	.003
	PK	29.393	1	29.393	4.982	.026	.006
	PCK	7.870	1	7.870	3.447	.064	.004
	CtK	8.843	1	8.843	3.662	.056	.005
Certificate Acquisition Mode	CK	8.608	2	4.304	.758	.469	.002
	PK	15.463	2	7.731	1.310	.270	.003
	PCK	1.385	2	.692	.303	.739	.001
	CtK	8.678	2	4.339	1.797	.166	.004
Error	CK	4530.104	798	5.677			
	PK	4708.242	798	5.900			
	PCK	1822.199	798	2.283			
	CtK	1926.806	798	2.415			
Total	CK	83083.000	803				
	PK	85633.000	803				
	PCK	20915.000	803				
	CtK	19940.000	803				
Corrected Total	CK	4592.687	802				
	PK	4792.092	802				
	PCK	1847.044	802				
	CtK	1957.435	802				

Source: Fieldwork, 2023; a. R Squared = .014 (Adjusted R Squared = .009); b. R Squared = .017 (Adjusted R Squared = .013); c. R Squared = .013 (Adjusted R Squared = .009); d. R Squared = .016 (Adjusted R Squared = .011); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

As earlier explained (see p. 297-298), the significance level of the test of between-subjects effects was assessed at .01. From Table 55, the test of between-subjects effects results show that a statistically significant difference exists in teachers' knowledge regarding CK, $F(1, 798) = 7.04$; $p = .008$; partial $\eta^2 = .009$; PK, $F(1, 798) = 7.34$; $p = .007$; partial $\eta^2 = .009$; PCK, $F(1, 798) =$

7.19; $p = .007$; partial $\eta^2 = .009$; and CtK, $F(1, 798) = 5.56$; $p = .01$; partial $\eta^2 = .007$ across gender. The amount of variances (0.9%; 0.7%) explained in each dependent variable was negligible. However, no statistically significant differences were found in teachers' knowledge of CK, $F(1, 798) = 2.74$; $p = .09$; partial $\eta^2 = .003$; PK, $F(1, 798) = 4.98$; $p = .02$; partial $\eta^2 = .006$; PCK, $F(1, 798) = 3.44$; $p = .06$; partial $\eta^2 = .004$; and CtK, $F(1, 798) = 3.66$; $p = .05$; partial $\eta^2 = .005$ across their years of teaching experience. A negligible amount of variance (0.3%, 0.6%, 0.4%, and 0.5%, respectively) was explained in each dependent variable. Similarly, the results indicate no statistically significant difference in teachers' knowledge of CK, $F(2, 798) = .75$; $p = .46$; partial $\eta^2 = .002$; PK, $F(2, 798) = 1.31$; $p = .27$; partial $\eta^2 = .003$; PCK, $F(2, 798) = .30$; $p = .73$; partial $\eta^2 = .001$; and CtK, $F(2, 798) = 1.79$; $p = .16$; partial $\eta^2 = .004$ across their mode of certificate acquisition. In each dependent variable, a negligible amount of variance (0.2%, 0.3%, 0.1% and 0.4% respectively) was explained. This result implies that teachers' knowledge of the curriculum does not differ significantly across their mode of certificate acquisition when the effects of gender and years of teaching experience are controlled for.

Thirdly, One-Way MANCOVA was performed to examine whether teachers' CK, PK, PCK and CtK about the standards-based mathematics curriculum differ across their grade levels when years of teaching experience and gender were controlled for. A preliminary test of homogeneity of regression was performed to assess the interactions between the covariates (years of teaching experience and gender) and the independent variable (grade level) across the dependent variables (CK, PK, PCK and CtK). The results obtained are displayed in Table 56.

Table 56: Test of Homogeneity of Regression for Grade Level, Gender and Teaching Experience Across the Dependent Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	CK	439.901 ^a	17	25.877	4.891	.000
	PK	591.831 ^b	17	34.814	6.506	.000
	PCK	122.611 ^c	17	7.212	3.283	.000
	CtK	147.734 ^d	17	8.690	3.770	.000
Intercept	CK	16124.441	1	16124.441	3047.998	.000
	PK	16887.139	1	16887.139	3156.090	.000
	PCK	4143.702	1	4143.702	1886.305	.000
	CtK	3803.269	1	3803.269	1649.757	.000
Grade Level	CK	110.877	5	22.175	4.192	.001
	PK	102.985	5	20.597	3.849	.002
	PCK	30.398	5	6.080	2.768	.017
	CtK	20.839	5	4.168	1.808	.109
Gender	CK	1.752	1	1.752	.331	.565
	PK	.410	1	.410	.077	.782
	PCK	6.622	1	6.622	3.014	.083
	CtK	.099	1	.099	.043	.836
Teaching Experience	CK	8.183	1	8.183	1.547	.214
	PK	17.365	1	17.365	3.245	.072
	PCK	11.129	1	11.129	5.066	.025
	CtK	8.607	1	8.607	3.734	.054
Grade Level * Gender	CK	15.500	5	3.100	.586	.711
	PK	19.749	5	3.950	.738	.595
	PCK	26.386	5	5.277	2.402	.036
	CtK	5.340	5	1.068	.463	.804
Grade Level * Teaching Experience	CK	26.237	5	5.247	.992	.422
	PK	56.644	5	11.329	2.117	.061
	PCK	23.552	5	4.710	2.144	.058
	CtK	4.593	5	.919	.398	.850
Error	CK	4152.786	785	5.290		
	PK	4200.261	785	5.351		
	PCK	1724.433	785	2.197		
	CtK	1809.701	785	2.305		
Total	CK	83083.000	803			
	PK	85633.000	803			
	PCK	20915.000	803			
	CtK	19940.000	803			
Corrected Total	CK	4592.687	802			
	PK	4792.092	802			
	PCK	1847.044	802			
	CtK	1957.435	802			

Source: Fieldwork, 2023; a. R Squared = .096 (Adjusted R Squared = .076); b. R Squared = .124 (Adjusted R Squared = .105); c. R Squared = .066 (Adjusted R Squared = .046); d. R Squared = .075 (Adjusted R Squared = .055); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

From Table 56, the results of the test of homogeneity of regression show that there were no significant interactions between grade level and gender (grade

level * gender) for CK [$F(5, 785) = .58; p = .71$]; PK [$F(5, 785) = .73; p = .59$]; CtK [$F(5, 785) = .46; p = .80$], except for PCK [$F(5, 785) = 2.40; p = .03$]. Further, the results indicate that the interactions between grade level and teaching experience (grade level * teaching experience) were not significant for CK [$F(5, 785) = .99; p = .42$]; PK [$F(5, 785) = 2.11; p = .061$]; PCK [$F(5, 785) = 2.14; p = .05$] and CtK [$F(5, 785) = .39; p = .85$]. The results show that the interaction between the independent variable (grade level) and covariates (gender and teaching experience) is insignificant indicating no violations of the homogeneity of regression assumption. The results of the “Box’s test of equality of covariance matrices” were examined to assess whether the “covariance matrices” of the continuous dependent variables (CK, PK, PCK and CtK) are equal across the independent variable (grade level). The results obtained are displayed in Table 57.

Table 57: Box’s Test of Equality of Covariance Matrices of the Dependent Variables Across Grade Level

	Box's M	F	df1	df2	Sig.
Value	139.329	2.751	50	1158667.205	.000

Source: Fieldwork, 2023

The result of the Box’s test in Table 57 is significant [Box's M = 139.329; $F(50, 1158667) = 2.75; p < .001$]. This indicates that the “covariance matrices” of the dependent variables (CK, PK, PCK and CtK) are not equal across the independent variable (grade level). Hence, this assumption is not met. Critics, however, point out that when your sample is bigger (in my case $n = 803$), the more sensitive it is to this test and the more likely it is to claim a result that is significant statistically when none exists (Schreiber-Gregory, 2018). To address this, many scholars (Jadhav & Dolas, 2023; Sheehan-Holt, 1998;

Tabachnick & Fidell, 2001; Tabachnick, Fidell, & Ullman, 2007) maintain that when this assumption is violated, instead of reporting “Wilks’ Lambda statistic”, one should report using “Pillai’s Trace statistic” because of its robustness. As a result, reporting was done using “Pillai’s Trace statistic”. Additionally, “Levene’s Test of equality of error variance was inspected to ascertain whether the variance of the dependent variables (CK, PK, PCK and CtK) is equal across the independent variable (grade level). The results obtained are displayed in Table 58.

Table 58: Levene's Test of Equality of Error Variances of the Dependent Variables Across Grade Level

	F	df1	df2	Sig.
CK	2.771	5	797	.017
PK	2.315	5	797	.042
PCK	4.658	5	797	.000
CtK	6.587	5	797	.000

Source: Fieldwork, 2023

From Table 58, the results of “Levene’s test of equality of error variance reveal that there are no equal variances of CK, [$F(5, 797) = 2.77; p = .01$]; PK, [$F(5, 797) = 2.31; p = .04$]; PCK, [$F(5, 797) = 4.65; p < .001$] and CtK, [$F(5, 797) = 6.58; p < .001$] across the independent variable (grade level). This implies that the assumption is violated. However, Field (2013) argues that this test is not always sufficient to establish if there are unequal variances to create problems. Critics also argue that when your sample is bigger (in my case $n = 803$), this test turns out to be unreliable. Hence, a “rule of thumb” as recommended by Field (2013) was further employed. In this, you inspect the biggest variance and the smallest variance in each level of the independent

variable (in my case grade levels). You then divide the biggest variance by the smallest variance to establish your “variance ratio (VR)”. A VR value less than 2 suggests equal variance of the dependent variable across the groups whereas a VR value greater than 2 suggests unequal variance of the dependent variable across the groups. The results are displayed in Table 59.

Table 59: Homogeneity of Variance of the Dependent Variables Across Grade Level

Grade		Std. Deviation	Variance	Variance Ratio (VR)	VR Decision
CK	Basic 1	2.380	5.664	1.723	<2
	Basic 2	1.852	3.429		
	Basic 3	2.431	5.909		
	Basic 4	2.258	5.098		
	Basic 5	2.373	5.631		
	Basic 6	2.419	5.851		
PK	Basic 1	2.401	5.764	1.660	<2
	Basic 2	2.131	4.541		
	Basic 3	2.000	4.000		
	Basic 4	2.471	6.105		
	Basic 5	2.577	6.640		
	Basic 6	2.312	5.345		
PCK	Basic 1	1.806	3.272	1.836	<2
	Basic 2	1.335	1.782		
	Basic 3	1.398	1.954		
	Basic 4	1.364	1.860		
	Basic 5	1.574	2.477		
	Basic 6	1.416	2.005		
CtK	Basic 1	2.002	4.008	2.398	>2
	Basic 2	1.431	2.047		
	Basic 3	1.293	1.671		
	Basic 4	1.313	1.723		
	Basic 5	1.594	2.540		
	Basic 6	1.316	1.731		

Source: Fieldwork, 2023

From Table 59, the VR value for CK across the grade levels is 1.723 which is less than 2 (<2) implying equal variance across the groups. Similarly, the VR value for PK across the grade levels is 1.660 less than 2 (<2) suggesting

an equal variance across the groups. Equally, the VR value for PCK across the grade levels is 1.836 less than 2 (<2) indicating equal variance across the groups whereas the VR value for CtK across the grade levels is slightly above 2 (>2) suggesting an unequal variance across the groups. Hence, reporting was done using “Pillai's Trace statistic” because of its robustness as many scholars (Jadhav & Dolas, 2023; Sheehan-Holt, 1998; Tabachnick & Fidell, 2001; Tabachnick, Fidell, & Ullman, 2007) recommend rather than using "Wilks' Lambda statistic" when you suspect any violation of an assumption. After assessing these assumptions, the results of One-Way MANCOVA were further generated. The results obtained are presented in Table 60.

Table 60: One-Way MANCOVA Results for Teachers' Knowledge Across Their Grade Level, Gender and Teaching Experience

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.898	1737.692 ^b	4.000	792.000	.000	.898
	Wilks' Lambda	.102	1737.692 ^b	4.000	792.000	.000	.898
	Hotelling's Trace	8.776	1737.692 ^b	4.000	792.000	.000	.898
	Roy's Largest Root	8.776	1737.692 ^b	4.000	792.000	.000	.898
Gender	Pillai's Trace	.002	.433 ^b	4.000	792.000	.785	.002
	Wilks' Lambda	.998	.433 ^b	4.000	792.000	.785	.002
	Hotelling's Trace	.002	.433 ^b	4.000	792.000	.785	.002
	Roy's Largest Root	.002	.433 ^b	4.000	792.000	.785	.002
Teaching Experience	Pillai's Trace	.010	2.093 ^b	4.000	792.000	.080	.010
	Wilks' Lambda	.990	2.093 ^b	4.000	792.000	.080	.010
	Hotelling's Trace	.011	2.093 ^b	4.000	792.000	.080	.010
	Roy's Largest Root	.011	2.093 ^b	4.000	792.000	.080	.010
Grade Level	Pillai's Trace	.161	6.687	20.000	3180.000	.000	.040
	Wilks' Lambda	.839	7.126	20.000	2627.717	.000	.043
	Hotelling's Trace	.191	7.532	20.000	3162.000	.000	.045
	Roy's Largest Root	.186	29.536 ^c	5.000	795.000	.000	.157

Source: Fieldwork, 2023; b. Exact statistic

From Table 60, the results of the multivariate test show that the effect of gender as a covariate was statistically insignificant, [Pillai's Trace, $V_{PT} = .980$; $F(4, 792) = .43$; $p = .78$; partial $\eta^2 = .002$], accounting for 0.2% of the variance in teachers' knowledge. Using Cohen's (1988) criteria, teachers' gender explained a negligible amount of variance (0.2%) in their knowledge. Similarly, the effect of years of experience in teaching as a covariate was statistically insignificant, $V_{PT} = .010$; $F(4, 792) = 2.09$; $p = .08$; partial $\eta^2 = .010$, accounting for a small amount of variance (1.0%) in teachers' knowledge. Overall, the One-Way MANCOVA results show a statistically significant difference in teachers' knowledge across their grade levels, $V_{PT} = .161$; $F(20, 3180) = 6.68$; $p < .001$; partial $\eta^2 = .040$, when the effects of their gender and years of teaching experience were controlled for. The amount of variance (4.0%) in teachers' knowledge of the curriculum due to their grade level was small. Further, the tests of between-subjects effects were examined. The results obtained are displayed in Table 61.

Table 61: Tests of Between-Subjects Effects on Teachers' Knowledge Across Their Grade Level, Gender and Teaching Experience

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	CK	394.880 ^a	7	56.411	10.683	.000	.086
	PK	509.764 ^b	7	72.823	13.519	.000	.106
	PCK	80.570 ^c	7	11.510	5.180	.000	.044
	CtK	138.154 ^d	7	19.736	8.624	.000	.071
Intercept	CK	17662.380	1	17662.380	3344.982	.000	.808
	PK	18320.914	1	18320.914	3401.217	.000	.811
	PCK	4467.534	1	4467.534	2010.610	.000	.717
	CtK	4124.399	1	4124.399	1802.304	.000	.694
Gender	CK	.055	1	.055	.010	.919	.000
	PK	.001	1	.001	.000	.989	.000
	PCK	3.553	1	3.553	1.599	.206	.002
	CtK	.063	1	.063	.028	.868	.000
Teaching Experience	CK	14.841	1	14.841	2.811	.094	.004
	PK	22.127	1	22.127	4.108	.043	.005
	PCK	6.740	1	6.740	3.034	.082	.004
	CtK	6.616	1	6.616	2.891	.089	.004

Table 61, Continued

Grade Level	CK	340.905	5	68.181	12.912	.000	.075
	PK	441.376	5	88.275	16.388	.000	.093
	PCK	57.110	5	11.422	5.140	.000	.031
	CtK	116.202	5	23.240	10.156	.000	.060
Error	CK	4197.807	795	5.280			
	PK	4282.328	795	5.387			
	PCK	1766.474	795	2.222			
	CtK	1819.281	795	2.288			
Total	CK	83083.000	803				
	PK	85633.000	803				
	PCK	20915.000	803				
	CtK	19940.000	803				
Corrected Total	CK	4592.687	802				
	PK	4792.092	802				
	PCK	1847.044	802				
	CtK	1957.435	802				

Source: Fieldwork, 2023; a. R Squared = .086 (Adjusted R Squared = .078); b. R Squared = .106 (Adjusted R Squared = .099); c. R Squared = .044 (Adjusted R Squared = .035); d. R Squared = .071 (Adjusted R Squared = .062); CK (content knowledge); PK (pedagogical knowledge); PCK (pedagogical content knowledge); CtK (contextual knowledge)

As explained previously (see p. 297-298), the significance level of the test of between-subjects effects was assessed at .01. From Table 61, the test of between-subjects effects results shows no statistically significant difference in teachers' knowledge regarding CK, $F(1, 795) = .01$; $p = .91$; partial $\eta^2 = .000$; PK, $F(1, 795) = .00$; $p = .98$; partial $\eta^2 = .000$; PCK, $F(1, 795) = 1.59$; $p = .20$; partial $\eta^2 = .002$; and CtK, $F(1, 795) = .02$; $p = .86$; partial $\eta^2 = .000$ across gender. The amount of variances (0.0%; 0.2%) explained in each dependent variable was negligible. Similarly, no statistically significant differences were found in teachers' knowledge of CK, $F(1, 795) = 2.81$; $p = .09$; partial $\eta^2 = .004$; PK, $F(1, 795) = 4.10$; $p = .04$; partial $\eta^2 = .005$; PCK, $F(1, 795) = 3.03$; $p = .08$; partial $\eta^2 = .004$; and CtK, $F(1, 795) = 2.89$; $p = .08$; partial $\eta^2 = .004$ across their years of teaching experience.

A negligible amount of variance (0.4%, 0.5%, 0.4%, and 0.4%, respectively) was explained in each dependent variable. However, the results

indicate a statistically significant difference in teachers' knowledge of CK, $F(5, 795) = 12.91; p < .001$; partial $\eta^2 = .075$; PK, $F(5, 795) = 16.38; p < .001$; partial $\eta^2 = .093$; PCK, $F(5, 795) = 5.14; p < .001$; partial $\eta^2 = .031$; and CtK, $F(5, 795) = 10.15; p < .001$; partial $\eta^2 = .060$ across their grade levels. A medium amount of variance was explained in CK (7.5%), PK (9.3%) and CtK (6.0%) while the amount of variance explained in PCK (3.1%) was small. This result implies that teachers' knowledge of the curriculum differs significantly across their grade levels when gender and years of teaching experience are controlled for.

Further inspection of the differences in teachers' knowledge across their grade levels was done by checking the "pairwise comparisons" based on "Bonferroni's adjustment". The mean difference was assessed based on the "estimated marginal means". The "estimated marginal means" were first presented in Table 62.

Table 62: Estimated Marginal Means of Teachers' Knowledge Across Their Grade Levels

Dependent Variable	Grade Level	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
CK	Basic 1	10.485 ^a	.202	10.088	10.882
	Basic 2	10.438 ^a	.207	10.032	10.845
	Basic 3	10.207 ^a	.196	9.822	10.592
	Basic 4	10.305 ^a	.199	9.914	10.695
	Basic 5	9.157 ^a	.201	8.762	9.552
	Basic 6	8.721 ^a	.206	8.317	9.125
PK	Basic 1	10.707 ^a	.204	10.306	11.108
	Basic 2	10.710 ^a	.209	10.299	11.120
	Basic 3	10.243 ^a	.198	9.854	10.632
	Basic 4	10.574 ^a	.201	10.179	10.969
	Basic 5	9.308 ^a	.203	8.909	9.707
	Basic 6	8.660 ^a	.208	8.252	9.068
PCK	Basic 1	5.071 ^a	.131	4.813	5.328
	Basic 2	5.092 ^a	.134	4.829	5.356
	Basic 3	4.852 ^a	.127	4.603	5.102

Table 62, Continued

CtK	Basic 4	5.183 ^a	.129	4.930	5.437
	Basic 5	4.632 ^a	.131	4.375	4.888
	Basic 6	4.409 ^a	.134	4.146	4.671
	Basic 1	5.032 ^a	.133	4.770	5.293
	Basic 2	5.048 ^a	.136	4.780	5.315
	Basic 3	4.869 ^a	.129	4.616	5.123
	Basic 4	5.015 ^a	.131	4.758	5.272
	Basic 5	4.477 ^a	.132	4.216	4.737
	Basic 6	3.953 ^a	.136	3.687	4.219

Source: Fieldwork, 2023; a. Covariates appearing in the model are evaluated at the following values: teachers' gender = .45, years of experience in teaching = 11.20.

From Table 62, adjusting for the effects of teachers' gender and years of experience in teaching (covariates), the “estimated marginal means” (EMMs) results show that for teachers' content knowledge (CK) about the curriculum in terms of knowledge of the organisation and structure of the curriculum, knowledge of expected learning behaviours, knowledge of instructional expectations of the curriculum and knowledge of the core competencies, Basic 1 teachers demonstrated highest knowledge [EMM = 10.48; S.E = .20; 95% CI (10.08, 10.88)], followed by teachers in Basic 2 [EMM = 10.43; S.E = .20; 95% CI (10.03, 10.84)], Basic 4 [EMM = 10.30; S.E = .19; 95% CI (9.91, 10.69)] and Basic 3 [EMM = 10.20; S.E = .19; 95% CI (9.82, 10.59)]. Both teachers in Basic 5 [EMM = 9.15; S.E = .20; 95% CI (8.76, 9.55)] and Basic 6 [EMM = 8.72; S.E = .20; 95% CI (8.31, 9.12)] recorded the least “estimated marginal mean” scores regarding their CK about the curriculum.

Concerning teachers' pedagogical knowledge (PK) about the curriculum in terms of knowledge of centred pedagogy, knowledge of inclusion and equity pedagogy, knowledge of differentiation and scaffolding pedagogy and knowledge of ICT as a pedagogical tool, teachers in Basic 2 exhibited the highest knowledge [EMM = 10.71; S. E = .20; 95% CI (10.29, 11.12)], followed

by Basic 1 teachers [EMM = 10.70; S.E = .20; 95% CI (10.30, 11.10)], teachers in Basic 4 [EMM = 10.57; S.E = .20; 95% CI (10.17, 10.96)] and Basic 3 teachers [EMM = 10.24; S.E = .19; 95% CI (9.85, 10.63)]. Teachers in Basic 5 [EMM = 9.30; S.E = .20; 95% CI (8.90, 9.70)] and Basic 6 [EMM = 8.66; S.E = .20; 95% CI (8.25, 9.06)] had the lowest “estimated marginal mean” scores on their pedagogical knowledge about the curriculum.

Regarding teachers’ pedagogical content knowledge (PCK) about the curriculum in terms of knowledge of recommended assessment practices and knowledge of learners’ learning, teachers in Basic 4 demonstrated the highest knowledge [EMM = 5.18; S.E = .12; 95% CI (4.93, 5.43)], followed by Basic 2 teachers [EMM = 5.09; S.E = .13; 95% CI (4.82, 5.35)], teachers in Basic 1 [EMM = 5.07; S.E = .13; 95% CI (4.81, 5.32)] and Basic 3 teachers [EMM = 4.85; S.E = .12; 95% CI (4.60, 5.10)]. The teachers who recorded the lowest “estimated marginal mean” scores on PCK regarding the curriculum were those in Basic 5 [EMM = 4.63; S.E = .13; 95% CI (4.37, 4.88)] and Basic 6 [EMM = 4.40; S.E = .13; 95% CI (4.14, 4.67)].

For teachers’ contextual knowledge (CtK) about the curriculum in terms of knowledge of learning contexts (classroom, school, community and culture) and the learner, teachers in Basic 2 exhibited the highest knowledge [EMM = 5.04; S.E = .13; 95% CI (4.78, 5.31)], followed by Basic 1 teachers [EMM = 5.03; S.E = .13; 95% CI (4.77, 5.29)], teachers in Basic 4 [EMM = 5.01; S.E = .13; 95% CI (4.75, 5.27)] and Basic 3 teachers [EMM = 4.86; S.E = .12; 95% CI (4.61, 5.12)]. Both teachers in Basic 5 [EMM = 4.47; S.E = .13; 95% CI (4.21, 4.73)] and Basic 6 [EMM = 3.95; S.E = .13; 95% CI (3.68, 4.21)] recorded the least mean scores regarding CtK about the curriculum. Following this, the

“pairwise comparisons” results of teachers’ knowledge across the various grade levels based on the “estimated marginal means” were assessed. The results obtained are displayed in Table 63.

Table 63: Pairwise Comparisons of Teachers’ Knowledge Across Their Grade Levels

Dependent Variable	(I) grade level	(J) grade level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference ^b	
						Lower Bound	Upper Bound
CK	Basic 1	Basic 2	.046	.284	1.000	-.791	.884
		Basic 3	.278	.280	1.000	-.546	1.101
		Basic 4	.180	.288	1.000	-.668	1.028
		Basic 5	1.328*	.289	.000	.478	2.178
		Basic 6	1.764*	.297	.000	.890	2.638
		Basic 2	-.046	.284	1.000	-.884	.791
	Basic 2	Basic 3	.231	.284	1.000	-.606	1.068
		Basic 4	.134	.290	1.000	-.721	.988
		Basic 5	1.281*	.291	.000	.424	2.138
		Basic 6	1.717*	.296	.000	.846	2.589
		Basic 3	-.278	.280	1.000	-1.101	.546
		Basic 2	-.231	.284	1.000	-1.068	.606
	Basic 3	Basic 4	-.098	.280	1.000	-.922	.727
		Basic 5	1.050*	.281	.003	.221	1.879
		Basic 6	1.486*	.287	.000	.641	2.332
		Basic 1	-.180	.288	1.000	-1.028	.668
		Basic 2	-.134	.290	1.000	-.988	.721
		Basic 3	.098	.280	1.000	-.727	.922
	Basic 4	Basic 5	1.148*	.281	.001	.321	1.975
		Basic 6	1.584*	.284	.000	.748	2.419
		Basic 1	-1.328*	.289	.000	-2.178	-.478
		Basic 2	-1.281*	.291	.000	-2.138	-.424
		Basic 3	-1.050*	.281	.003	-1.879	-.221
		Basic 4	-1.148*	.281	.001	-1.975	-.321
	Basic 5	Basic 6	.436	.286	1.000	-.405	1.277
		Basic 1	-1.764*	.297	.000	-2.638	-.890
		Basic 2	-1.717*	.296	.000	-2.589	-.846
		Basic 3	-1.486*	.287	.000	-2.332	-.641
		Basic 4	-1.584*	.284	.000	-2.419	-.748
		Basic 5	-.436	.286	1.000	-1.277	.405
PK	Basic 1	Basic 2	-.003	.287	1.000	-.848	.843
		Basic 3	.464	.283	1.000	-.368	1.296
		Basic 4	.133	.291	1.000	-.723	.989
		Basic 5	1.399*	.292	.000	.540	2.257
		Basic 6	2.047*	.300	.000	1.165	2.930
		Basic 2	.003	.287	1.000	-.843	.848
	Basic 2	Basic 3	.467	.287	1.000	-.379	1.312
		Basic 4	.136	.293	1.000	-.727	.998
		Basic 5	1.401*	.294	.000	.536	2.267
		Basic 6	2.050*	.299	.000	1.169	2.930
	Basic 3	Basic 1	-.464	.283	1.000	-1.296	.368
		Basic 2	-.467	.287	1.000	-1.312	.379

Table 63, Continued

PCK	Basic 4	Basic 4	-.331	.283	1.000	-1.164	.502
		Basic 5	.935*	.284	.016	.098	1.772
		Basic 6	1.583*	.290	.000	.729	2.437
		Basic 1	-.133	.291	1.000	-.989	.723
		Basic 2	-.136	.293	1.000	-.998	.727
		Basic 3	.331	.283	1.000	-.502	1.164
	Basic 5	Basic 5	1.266*	.284	.000	.431	2.101
		Basic 6	1.914*	.287	.000	1.070	2.758
		Basic 1	-1.399*	.292	.000	-2.257	-.540
		Basic 2	-1.401*	.294	.000	-2.267	-.536
		Basic 3	-.935*	.284	.016	-1.772	-.098
		Basic 4	-1.266*	.284	.000	-2.101	-.431
	Basic 6	Basic 6	.648	.289	.374	-.201	1.498
		Basic 1	-2.047*	.300	.000	-2.930	-1.165
		Basic 2	-2.050*	.299	.000	-2.930	-1.169
		Basic 3	-1.583*	.290	.000	-2.437	-.729
		Basic 4	-1.914*	.287	.000	-2.758	-1.070
		Basic 5	-.648	.289	.374	-1.498	.201
	Basic 1	Basic 2	-.021	.185	1.000	-.565	.522
		Basic 3	.218	.181	1.000	-.316	.753
		Basic 4	-.113	.187	1.000	-.663	.437
		Basic 5	.439	.187	.289	-.112	.990
		Basic 6	.662*	.193	.009	.095	1.229
	Basic 2	Basic 1	.021	.185	1.000	-.522	.565
		Basic 3	.240	.184	1.000	-.303	.783
		Basic 4	-.091	.188	1.000	-.645	.463
		Basic 5	.461	.189	.224	-.095	1.016
		Basic 6	.684*	.192	.006	.118	1.249
	Basic 3	Basic 1	-.218	.181	1.000	-.753	.316
		Basic 2	-.240	.184	1.000	-.783	.303
		Basic 4	-.331	.182	1.000	-.866	.204
		Basic 5	.221	.183	1.000	-.317	.758
		Basic 6	.444	.186	.262	-.105	.992
	Basic 4	Basic 1	.113	.187	1.000	-.437	.663
		Basic 2	.091	.188	1.000	-.463	.645
		Basic 3	.331	.182	1.000	-.204	.866
		Basic 5	.552*	.182	.038	.015	1.088
		Basic 6	.775*	.184	.000	.233	1.317
	Basic 5	Basic 1	-.439	.187	.289	-.990	.112
		Basic 2	-.461	.189	.224	-1.016	.095
		Basic 3	-.221	.183	1.000	-.758	.317
		Basic 4	-.552*	.182	.038	-1.088	-.015
		Basic 6	.223	.185	1.000	-.323	.769
	Basic 6	Basic 1	-.662*	.193	.009	-1.229	-.095
		Basic 2	-.684*	.192	.006	-1.249	-.118
		Basic 3	-.444	.186	.262	-.992	.105
		Basic 4	-.775*	.184	.000	-1.317	-.233
		Basic 5	-.223	.185	1.000	-.769	.323
CtK	Basic 1	Basic 2	-.016	.187	1.000	-.567	.535
		Basic 3	.162	.184	1.000	-.380	.705
		Basic 4	.016	.190	1.000	-.542	.575
		Basic 5	.555	.190	.054	-.004	1.115
		Basic 6	1.079*	.195	.000	.504	1.654
	Basic 2	Basic 1	.016	.187	1.000	-.535	.567

Table 63, Continued

	Basic 3	.178	.187	1.000	-.373	.729
	Basic 4	.033	.191	1.000	-.530	.595
	Basic 5	.571*	.192	.044	.007	1.135
	Basic 6	1.095*	.195	.000	.521	1.669
Basic 3	Basic 1	-.162	.184	1.000	-.705	.380
	Basic 2	-.178	.187	1.000	-.729	.373
	Basic 4	-.146	.184	1.000	-.689	.397
	Basic 5	.393	.185	.514	-.153	.938
	Basic 6	.916*	.189	.000	.360	1.473
Basic 4	Basic 1	-.016	.190	1.000	-.575	.542
	Basic 2	-.033	.191	1.000	-.595	.530
	Basic 3	.146	.184	1.000	-.397	.689
	Basic 5	.539	.185	.055	-.006	1.083
	Basic 6	1.062*	.187	.000	.512	1.612
Basic 5	Basic 1	-.555	.190	.054	-1.115	.004
	Basic 2	-.571*	.192	.044	-1.135	-.007
	Basic 3	-.393	.185	.514	-.938	.153
	Basic 4	-.539	.185	.055	-1.083	.006
	Basic 6	.524	.188	.083	-.030	1.077
Basic 6	Basic 1	-1.079*	.195	.000	-1.654	-.504
	Basic 2	-1.095*	.195	.000	-1.669	-.521
	Basic 3	-.916*	.189	.000	-1.473	-.360
	Basic 4	-1.062*	.187	.000	-1.612	-.512
	Basic 5	-.524	.188	.083	-1.077	.030

Source: Fieldwork, 2023; b. Adjustment for comparisons: Bonferroni; *. The mean difference is significant at the .05 level; CK (content knowledge); PK (pedagogical knowledge; PCK (pedagogical content knowledge); CtK (contextual knowledge)

From Table 63, the results of the “pairwise comparison based on Bonferroni’s adjustment” show that, the mean difference (MD) in teachers’ CK between Basic 1 and Basic 5 was statistically significant, [MD = 1.32; $p < .001$; 95% CI (.47, 2.17)], between Basic 1 and Basic 6 reached a statistically significant level, [MD = 1.76; $p < .001$; 95% CI (.89, 2.63)], between Basic 2 and Basic 5 was significant, [MD = 1.28; $p < .001$; 95% CI (.42, 2.13)], between Basic 2 and Basic 6 was found statistically significant, [MD = 1.71; $p < .001$; 95% CI (.84, 2.58)], between Basic 3 and Basic 5 was significant, [MD = 1.05; $p = .003$; 95% CI (.22, 1.87)], between Basic 3 and Basic 6 reached a statistically significant level, [MD = 1.48; $p < .001$; 95% CI (.64, 2.33)], between Basic 4 and Basic 5 was significant, [MD = 1.14; $p = .001$; 95% CI

(.32, 1.97)] and between Basic 4 and Basic 6 was found significant, [MD = 1.58; $p < .001$; 95% CI (.74, 2.41)].

The mean difference (MD) in teachers' PK between Basic 1 and Basic 5 was found statistically significant, [MD = 1.40; $p < .001$; 95% CI (.54, 2.25)], between Basic 1 and Basic 6 was significant, [MD = 2.04; $p < .001$; 95% CI (1.16, 2.93)], between Basic 2 and Basic 5 reached a statistically significant level, [MD = 1.40; $p < .001$; 95% CI (.53, 2.26)], between Basic 2 and Basic 6 was significant, [MD = 2.05; $p < .001$; 95% CI (1.16, 2.93)], between Basic 3 and Basic 5 was found statistically significant, [MD = .93; $p = .01$; 95% CI (.09, 1.77)], between Basic 3 and Basic 6 was significant, [MD = 1.58; $p < .001$; 95% CI (.72, 2.43)], between Basic 4 and Basic 5 was found significant, [MD = 1.26; $p < .001$; 95% CI (.43, 2.10)] and between Basic 4 and Basic 6 reached a statistically significant level, [MD = 1.91; $p < .001$; 95% CI (1.07, 2.75)].

Also, the mean difference (MD) in teachers' PCK between Basic 1 and Basic 6 was found statistically significant, [MD = .66; $p = .009$; 95% CI (.09, 1.22)], between Basic 2 and Basic 6 was significant, [MD = .68; $p = .006$; 95% CI (.11, 1.24)], between Basic 4 and Basic 5 reached a significant level, [MD = .55; $p = .03$; 95% CI (.01, 1.08)] and between Basic 4 and Basic 6 was statistically significant, [MD = .77; $p < .001$; 95% CI (.23, 1.31)]. Furthermore, the mean difference (MD) in teachers' CtK between Basic 1 and Basic 6 was found statistically significant, [MD = 1.07; $p < .001$; 95% CI (.50, 1.65)], between Basic 2 and Basic 5 was significant, [MD = .57; $p = .04$; 95% CI (.00, 1.13)], between Basic 2 and Basic 6 was statistically significant, [MD = 1.09; $p < .001$; 95% CI (.52, 1.66)], between Basic 3 and Basic 6 was found significant, [MD = .91; $p < .001$; 95% CI (.36, 1.47)] and statistically

significant level was attained between Basic 4 and Basic 6, [MD = 1.06; $p < .001$; 95% CI (.51, 1.61)].

The results indicate a difference in teachers' knowledge of the standards-based mathematics curriculum between teachers in lower grades (Basic 1, 2, 4 and 3) and upper grades (Basic 5 and 6). The results seem to suggest that teachers at Basic 1, Basic 2, Basic 4 and Basic 3 demonstrate moderately higher knowledge of the curriculum as compared to teachers in Basic 5 and Basic 6 who seem to demonstrate moderately lower knowledge of the standards-based mathematics curriculum.

Regarding the results in Table 63, further follow-up interviews were done to examine what could account for teachers' moderately higher knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4. Also, the follow-up interviews were done to ascertain what could account for teachers' moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6. The responses gathered were analysed thematically. Twenty-one (21) teachers' interviews were taken into account due to the saturation of the data. Out of the 21 interviews, 12 teachers were interviewed in Basic 1, 2, 3 and 4, and 9 teachers were interviewed in Basic 5 and 6. 40 codes were generated and grouped into 3 themes for the interviews done in Basic 1, 2, 3 and 4 while 45 codes were generated and grouped into 3 themes for the interviews done in Basic 5 and 6. The themes for Basic 1, 2, 3 and 4 constituted training on Differentiated Learning (DL) and Professional Learning Community (PLC), teachers' input, commitment and passion, and teachers' knowledge, experience and expertise. The themes for Basic 5 and 6 were the nature of the curriculum, inadequate training and workshops, and teachers' knowledge, attitudes,

expertise and experience. Below are the thematic presentations of these themes for Basic 1, 2, 3 and 4.

Training on the DL and PLC

From the interviews, it was observed that teachers in Basic 1, 2, 3 and 4 attributed what could account for their moderately higher knowledge regarding the standards-based mathematics curriculum to the training they receive from the DL and PLC. Here are a couple of comments from the teachers.

“Also, some training on the DL and PLC of the new curriculum. It is a section where we have designated a time for all teachers to come together, share and discuss issues pertaining to the curriculum implementation. The challenge we encounter we open up to colleagues we all bring our ideas and from that, we learn. We discuss how to different the content, learning activities and assessment so those who do not know learn” (Excerpt from Teacher 7).

“The training we normally receive regarding the DL and PLC has been beneficial. It is a period where colleague teachers discuss certain challenges they encounter and how best each can contribute to addressing them. Others also share their success stories regarding certain pedagogies they employ and how they do it. At times different people are invited to engage us” (Excerpt from Teacher 12).

“You see the constant practice of the DL and the PLC is helping. Most of us involve ourselves. The DL and PLC sections provide an avenue for us to share and discuss ideas about our teaching pedagogies and certain challenges we encounter. Through this, we acquire new knowledge for the implementation of the curriculum” (Excerpt from Teacher 19).

The teachers’ comments seem to suggest that the kind of training they receive from the DL and PLC regarding the standards-based mathematics curriculum implementation are some of the issues contributing to their knowledge about the curriculum. Their remarks seem to suggest that the training they are receiving from the DL and PLC is assisting them in acquiring more knowledge about the curriculum.

Teachers' Input, Commitment and Passion

From the interviews, it was noticed that teachers in Basic 1, 2, 3 and 4 credited what could account for their moderately higher knowledge regarding the standards-based mathematics curriculum to their input, commitment and passion. Here are a couple of comments from the teachers.

"This is as a result of the input of facilitators. I mean what facilitators themselves do. Their effort to understand the curriculum by engaging in training and other continuous professional development workshops" (Excerpt from Teacher 8).

"Teachers' commitment and allowing students to develop higher-order thinking, problem-solving, communication, and reasoning. I am referring to teachers' zeal to understand the curriculum. The kind of effort teachers make contributes to this knowledge" (Excerpt from Teacher 9).

"Teachers' passion for the curriculum could contribute to their knowledge. I am talking about teachers' level of commitment and interest in the curriculum" (Excerpt from Teacher 14).

The teachers' remarks seem to suggest that their input, commitment and passion they possess regarding the standards-based mathematics curriculum are the issues contributing to their knowledge. The teachers' comments seem to imply that the kind of effort they demonstrate, how committed they are and the interest they have in the curriculum are supporting them in acquiring more knowledge about the curriculum.

Teachers' Knowledge, Experience and Expertise

From the interviews, it was noted that teachers in Basic 1, 2, 3 and 4 ascribed what could account for their moderately higher knowledge regarding the standards-based mathematics curriculum to their knowledge, experience and expertise. Here are a couple of comments from the teachers.

"This to me is attributed to teachers' school experience. Most of the teachers in the lower grades have taught for long" (Excerpt from Teacher 16).

“To me, it bores down to experiences and assessment, learning climates, and reflections. I can also say instructional rigour and engagement, instructional relevance and knowledge of the content” (Excerpt from Teacher 5).

The teachers’ comments seem to suggest that the knowledge they possess, their own expertise and the experiences they have are some of the issues contributing to their knowledge about the standards-based mathematics curriculum. The teachers’ remarks seem to imply that the kind of experiences and expertise they exhibit assist them in acquiring more knowledge about the curriculum. On what could account for teachers’ moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6, the themes generated are presented in the sections below.

Nature of the Curriculum

From the interviews, it was observed that teachers in Basic 5 and 6 attributed what could account for their moderately lower knowledge regarding the standards-based mathematics curriculum to the nature of the curriculum. Here are a couple of comments from the teachers.

“Also, some of the topics are new since they were not in the previous curriculum. In a situation like this you know it will take time to grasp a concept and this alone can affect your knowledge” (Excerpt from Teacher 13).

“An upper grade is higher than a lower grade so its curriculum content and expectations may be higher. As you are moving higher from the lower grades to the upper grades, curriculum content and expectations may be demanding so this could affect teachers’ knowledge in the upper grades” (Excerpt from Teacher 15).

“You see because the curriculum is new some aspects are also new including some of the topics” (Excerpt from Teacher 17).

The remarks from the teachers seem to suggest that the nature of the curriculum in the upper grades in terms of the introduction of new topics, other new aspects and the upper grades’ content being higher than the lower grades are some of the issues contributing to moderately lower knowledge regarding

the standards-based mathematics curriculum as compared to the lower grades. The teachers' comments seem to imply that issues like the introduction of new topics, other new aspects and the upper grades' content being higher appear to account for their moderately lower knowledge of the curriculum.

Inadequate Training and workshops

From the interviews, it was noticed that teachers in Basic 5 and 6 ascribed what could account for their moderately lower knowledge regarding the standards-based mathematics curriculum to inadequate training and workshops. Here are a couple of comments from the teachers.

"Lack of continuous training could be a factor. Others could be teachers' own knowledge and attitudes they have. What I mean is that some teachers are not prepared to take the time to go through the curriculum themselves, and some are also not prepared to go for other training and workshops. If you do this what will happen is you will not understand and know anything about the curriculum" (Excerpt from Teacher 1).

"In my opinion, is because of low workshops and to some degree teachers' own knowledge about it. Teachers not having training regularly" (Excerpt from Teacher 11).

"I think not enough has been done on our training. A lot of training needs to be done on a regular basis. This could help us" (Excerpt from Teacher 20).

The comments from the teachers seem to suggest that inadequate training and workshops in the upper grades are some of the issues contributing to moderately lower knowledge regarding the standards-based mathematics curriculum as compared to the lower grades. The teachers' comments seem to imply that they are not receiving enough training and workshops about the curriculum which appears to account for their moderately lower knowledge of the curriculum.

Teachers' Knowledge, Attitudes, Expertise and Experience

From the interviews, it was observed that teachers in Basic 5 and 6 attributed what could account for their moderately lower knowledge regarding the standards-based mathematics curriculum to issues of the teachers' own knowledge they have, attitude they exhibit, expertise and level of experience. Here are a couple of comments from the teachers.

"Others could be teachers' own knowledge and attitudes they have. What I mean is that some teachers are not prepared to take the time to go through the curriculum themselves and some are also not prepared to go for other training and workshops. If you do this what will happen is you will not understand and know anything about the curriculum" (Excerpt from Teacher 1).

"I can say that is due to teachers' expertise they have, transition challenges, curriculum progression and lack of fundamental knowledge" (Excerpt from Teacher 15).

"Inadequate knowledge of the mathematics content relating to topics. What I am trying to put across is some of the teachers themselves have difficulties handling mathematics so because of their knowledge gap they do not try to learn more about the curriculum" (Excerpt from Teacher 18).

The remarks from the teachers seem to suggest that the teachers' own knowledge they possess, the attitude they demonstrate, expertise and experience they have in the upper grades are some of the issues contributing to moderately lower knowledge regarding the standards-based mathematics curriculum as compared to the lower grades. The teachers' comments seem to imply that the kind of knowledge, the attitude they show, and the expertise they demonstrate appear to account for their moderately lower knowledge of the curriculum.

Discussion of Results of Research Hypothesis One (Ho₁)

Hypothesis one (1) sought to ascertain whether a statistically significant difference exists in teachers' knowledge (content, pedagogical, pedagogical content and contextual knowledge) about the standards-based mathematics

curriculum across their academic qualifications, mode of certificate acquisition and grade levels when the effects of their years of teaching experience, age and gender are controlled for. Separate analyses of One-Way MANCOVA were done for each independent variable and the findings obtained are discussed below.

Firstly, the One-Way MANCOVA results revealed that no statistically significant difference exists in teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum across their qualifications when the effects of teachers' years of teaching experience and gender were controlled for. The effect of gender as a covariate was significant whereas the effect of years of experience in teaching as a covariate was insignificant. This result indicates that teachers' knowledge about the standards-based mathematics curriculum does not differ across the kind of academic qualifications teachers possess.

However, the effect of teachers' gender influences their knowledge across their academic qualifications while years of experience in teaching do not. This contradicts the findings of studies by Al-Awidi and Aldhafeeri (2017) and Madani and Forawi (2019), which found that teachers' knowledge varies significantly depending on their years of experience in teaching. Also, the finding seems to imply that regardless of teachers' academic qualifications, their knowledge about the standards-based mathematics curriculum seems to be the same. This current study's finding is contrary to the findings of Madani and Forawi (2019) who reported a statistically significant difference in teachers' awareness and knowledge about new mathematics and science curricula across their academic qualifications. The current study's finding appears to suggest

that the teachers' knowledge they possess about the curriculum seems to be similar, irrespective of their level of academic qualifications.

Secondly, the One-Way MANCOVA results showed that there is no statistically significant difference in teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum across their mode of certificate acquisition when the effects of teachers' years of teaching experience and gender were controlled for. The effect of gender as a covariate was significant whereas the effect of years of experience in teaching as a covariate was insignificant. This result indicates that teachers' knowledge about the standards-based mathematics curriculum does not differ across their mode of certificate acquisition.

However, the effect of teachers' gender influences their knowledge across their mode of certificate acquisition while years of experience in teaching do not. This is inconsistent with the findings of Al-Awidi and Aldhafeeri (2017) and Madani and Forawi (2019) whose studies revealed that teachers' knowledge significantly differs across their years of experience in teaching. The current study's finding seems to imply that whether a teacher acquires his/her education through distance, sandwich, regular or part-time their knowledge about the standards-based mathematics curriculum seems to be the same.

Thirdly, the One-Way MANCOVA results revealed that there is a statistically significant difference in teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum across their grade levels when the effects of teachers' years of teaching experience and gender were controlled for. The effects of both gender and years of experience in teaching as covariates were found to be

insignificant. This result indicates that teachers' knowledge about the standards-based mathematics curriculum differs across the grade levels they teach. However, the effects of teachers' gender and years of experience in teaching did not influence teachers' knowledge across the grade levels. This contradicts the findings of studies by Al-Awidi and Aldhafeeri (2017) and Madani and Forawi (2019), which found that teachers' knowledge varies significantly depending on their years of experience in teaching.

Also, the current study's finding is contrary to the findings of Al-Awidi and Aldhafeeri (2017) who revealed that teachers' pedagogical readiness to implement a curriculum does not differ significantly across their grade levels. The current study's finding suggests that teachers' knowledge of content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum is not the same across the grade levels they teach. The current study's finding indicates a difference in teachers' knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3, 4, 5 and 6. The findings seem to suggest that teachers in Basic 1, Basic 2, Basic 4 and Basic 3 demonstrate moderately higher knowledge of the curriculum as compared to teachers in Basic 5 and Basic 6 who seem to demonstrate moderately lower knowledge of the standards-based mathematics curriculum.

A follow-up interview analysis on what could account for teachers' moderately higher knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4 reveals that teachers attributed this to training on the DL and PLC, teachers' input, commitment and passion, and teachers' knowledge, expertise and experience. On what could account for teachers' moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6,

teachers ascribed this to the nature of the curriculum at the upper grades as being comprised of new topics and other new aspects, inadequate training and workshops, and teachers' own knowledge, attitudes, expertise and experience they possess. The current study's findings seem to indicate that teachers' training, knowledge, experience and expertise are crucial for the implementation. These seem to be key indicators for teachers' moderately higher knowledge regarding the curriculum in Basic 1, 2, 3 and 4, and teachers' moderately lower knowledge of the curriculum in Basic 5 and 6. As found in Isaboke's (2021) study, teachers exposed to training on the competency-based curriculum (CBC) exhibited an appreciable level of knowledge and integration of the various core competencies as compared to non-trained teachers.

Research Hypothesis Two (H₀₂): There is no significant difference in teachers' standards-based mathematics curriculum implementation across grade levels, controlling for the effects of years of experience in teaching, age and gender.

This research hypothesis sought to examine whether a statistically significant difference exists in teachers' standards-based mathematics curriculum implementation across their grade levels when the effects of their years of experience in teaching, age and gender are controlled for. A One-Way ANCOVA was employed for analysing the data through SPSS versions 22 and 27. Teachers' standards-based mathematics curriculum implementation was entered as a continuous dependent variable, teachers' grade level was keyed as an independent variable, and teachers' years of experience in teaching and gender were entered as controlling variables (covariates) in SPSS.

Since the correlation between years of experience in teaching and age was found to be highly correlated (see Table 44, p. 298), age was dropped as a covariate and not included in the SPSS. As many scholars (Chavent, Lacaille, Mourer & Olteanu, 2021; Chowdhury & Turin, 2020; Freckleton, 2011) agree that when you have two highly correlated variables, it is prudent to consider removing one of such variables. Also, the normality test of the teachers' implementation scores was addressed by checking the mean, 5% trimmed mean, median, skewness and kurtosis values (see Table 43, p. 286) and the histogram with normality curve and normal Q-Q plot (see Figure 12, p. 287-288). The results obtained for the mean, 5% trimmed mean, median, skewness and kurtosis values and the visual inspection of the histogram with normality curve and normal Q-Q plot showed that the implementation scores were approximately normally distributed.

A preliminary “test of homogeneity of regression” was performed to assess the interactions between the covariates (years of teaching experience and gender) and the independent variable (grade level) across the dependent variable (implementation scores). The results obtained are presented in Table 64.

Table 64: Test of Homogeneity of Regression for Grade Level, Gender and Teaching Experience Across the Implementation

Dependent Variable: Implementation Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	53235.532 ^a	17	3131.502	24.759	.000
Intercept	759760.604	1	759760.604	6006.999	.000
Grade Level	7399.575	5	1479.915	11.701	.000
Gender	.050	1	.050	.000	.984
Teaching Experience	164.442	1	164.442	1.300	.255
Grade Level * Gender	945.754	5	189.151	1.496	.189

Table 64, Continued

Grade Level * Teaching Experience	1125.240	5	225.048	1.779	.115
Error	99286.194	785	126.479		
Total	3895574.000	803			
Corrected Total	152521.726	802			

Source: Fieldwork, 2023; a. R Squared = .349 (Adjusted R Squared = .335)

From Table 64, the results of the test of homogeneity of regression show that there were no significant interactions between grade level and gender (grade level * gender), $F(5, 785) = 1.49$; $p = .18$. Similarly, the results further indicate no significant interaction between grade level and teaching experience (grade level * teaching experience), $F(5, 785) = 1.77$; $p = .11$ across the implementation scores. The results show that the interaction between the independent variable (grade level) and the covariates (gender and teaching experience) is insignificant indicating no violations of this assumption.

Further, a residual plot was inspected visually to assess “the homogeneity of equal variance” of the dependent variable (implementation scores) across the independent variable (grade levels). Standardised residuals were used for the plot. Kutner, Nachtsheim, Neter and Li (2005) offer a solid basis for using residual plots when addressing the issue of “homogeneity of equal variance”. Similarly, according to Field (2013), when determining whether variances are equal or unequal, Levene’s test is not always the ideal approach for judgment. Hence, a residual plot was inspected as shown in Figure 13.

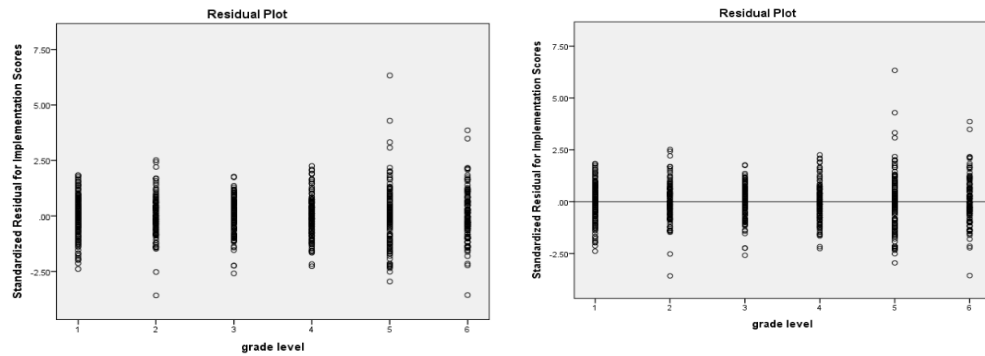


Figure 13: Residual Plot

Source: Fieldwork, 2023

From Figure 13, the spread of residuals across each level of the independent variable (grade level) is fairly similar. Also, the residuals that fall above and below the horizontal line that coincides with the zero (0) point are approximately equal. This indicates that there are equal variances of the implementation scores across the grade levels, demonstrating no violation of this assumption. After checking these preliminary assumptions, the results of the One-Way ANCOVA were generated. The results are displayed in Table 65.

Table 65: One-Way ANCOVA Results for Teachers' Implementation Scores Across Their Grade Level, Gender and Teaching Experience

Dependent Variable: Implementation Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	50712.489 ^a	7	7244.641	56.571	.000	.332
Intercept	810608.063	1	810608.063	6329.813	.000	.888
Gender	1.698	1	1.698	.013	.908	.000
Teaching Experience	30.542	1	30.542	.238	.625	.000
Grade Level	45868.418	5	9173.684	71.635	.000	.311
Error	101809.237	795	128.062			
Total	3895574.000	803				
Corrected Total	152521.726	802				

Source: Fieldwork, 2023; a. R Squared = .332 (Adjusted R Squared = .327)

From Table 65, the results show that the effect of gender as a covariate was statistically insignificant, $F(1, 795) = .01$; $p = .90$; partial $\eta^2 = .000$,

accounting for no (0.0%) variance in teachers' curriculum implementation. Similarly, the effect of years of experience in teaching as a covariate was found statistically insignificant, $F(1, 795) = .23$; $p = .62$; partial $\eta^2 = .000$, accounting for no (0.0%) variance in teachers' curriculum implementation. Overall, the One-Way ANCOVA results show a statistically significant difference in teachers' curriculum implementation across their grade level, $F(5, 795) = 71.63$; $p < .001$; partial $\eta^2 = .311$, when the effects of their gender and years of teaching experience were controlled for. The amount of variance (31.1%) in teachers' curriculum implementation due to their grade level was substantial. This result implies that teachers' curriculum implementation differs significantly across their grade levels when gender and years of teaching experience are controlled for.

A follow-up inspection of the differences in teachers' curriculum implementation across their grade levels was done by checking the "pairwise comparisons" based on "Bonferroni's adjustment". The mean difference was assessed based on the "estimated marginal means". The "estimated marginal means" were first presented in Table 66.

Table 66: Estimated Marginal Means for Teachers' Curriculum Implementation Across Their Grade Levels

Dependent Variable: Implementation Scores

Grade Level	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Basic 1	75.286 ^a	.997	73.329	77.242
Basic 2	70.786 ^a	1.020	68.784	72.788
Basic 3	73.278 ^a	.966	71.381	75.174
Basic 4	73.416 ^a	.980	71.491	75.340
Basic 5	64.256 ^a	.991	62.311	66.201
Basic 6	52.329 ^a	1.014	50.339	54.320

Source: Fieldwork, 2023; a. Covariates appearing in the model are evaluated at the following values: teachers' gender = .45, years of experience in teaching = 11.20

From Table 66, adjusting for the effects of teachers' gender and years of experience in teaching (covariates), the "estimated marginal means" (EMMs) results show that teachers in Basic 1 demonstrated the highest implementation of the curriculum [EMM = 75.28; S.E = .99; 95% CI (73.32, 77.24)], followed by teachers in Basic 4 [EMM = 73.41; S.E = .98; 95% CI (71.49, 75.34), teachers in Basic 3 [EMM = 73.27; S.E = .96; 95% CI (71.38, 75.17)] and Basic 2 teachers ([EMM =70.78; S.E = 1.02; 95% CI (68.78, 72.78)]. Teachers in Basic 5 [EMM =64.25; S.E = .99; 95% CI (62.31, 66.20)] and Basic 6 [EMM = 52.32; S.E = 1.01; 95% CI (50.33, 54.32)] had the lowest "estimated marginal mean" scores for the implementation indicating low implementation of the curriculum. Following this, the "pairwise comparisons" results of teachers' curriculum implementation across the various grade levels based on the "estimated marginal means" were assessed. The results obtained are displayed in Table 67.

Table 67: Pairwise Comparisons of Teachers' Curriculum Implementation Across Their Grade Levels

Dependent Variable: Implementation Scores

(I) grade level	(J) grade level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
Basic 1	Basic 2	4.500*	1.401	.021	.376	8.624
	Basic 3	2.008	1.378	1.000	-2.048	6.064
	Basic 4	1.870	1.418	1.000	-2.306	6.045
	Basic 5	11.030*	1.422	.000	6.844	15.215
	Basic 6	22.956*	1.462	.000	18.654	27.259
Basic 2	Basic 1	-4.500*	1.401	.021	-8.624	-.376
	Basic 3	-2.492	1.400	1.000	-6.613	1.630
	Basic 4	-2.630	1.429	.992	-6.837	1.578
	Basic 5	6.530*	1.433	.000	2.310	10.750
	Basic 6	18.457*	1.458	.000	14.164	22.749
Basic 3	Basic 1	-2.008	1.378	1.000	-6.064	2.048
	Basic 2	2.492	1.400	1.000	-1.630	6.613
	Basic 4	-.138	1.379	1.000	-4.198	3.922
	Basic 5	9.022*	1.386	.000	4.941	13.103
	Basic 6	20.948*	1.415	.000	16.784	25.113

Table 67, Continued

Basic 4	Basic 1	-1.870	1.418	1.000	-6.045	2.306
	Basic 2	2.630	1.429	.992	-1.578	6.837
	Basic 3	.138	1.379	1.000	-3.922	4.198
	Basic 5	9.160*	1.383	.000	5.088	13.232
	Basic 6	21.086*	1.398	.000	16.971	25.202
Basic 5	Basic 1	-11.030*	1.422	.000	-15.215	-6.844
	Basic 2	-6.530*	1.433	.000	-10.750	-2.310
	Basic 3	-9.022*	1.386	.000	-13.103	-4.941
	Basic 4	-9.160*	1.383	.000	-13.232	-5.088
	Basic 6	11.927*	1.407	.000	7.783	16.070
Basic 6	Basic 1	-22.956*	1.462	.000	-27.259	-18.654
	Basic 2	-18.457*	1.458	.000	-22.749	-14.164
	Basic 3	-20.948*	1.415	.000	-25.113	-16.784
	Basic 4	-21.086*	1.398	.000	-25.202	-16.971
	Basic 5	-11.927*	1.407	.000	-16.070	-7.783

Source: Fieldwork, 2023; b. Adjustment for comparisons: Bonferroni; *. The mean difference is significant at the .05 level.

From Table 67, the results of the “pairwise comparison based on Bonferroni’s adjustment” show that, the mean difference (MD) in teachers’ curriculum implementation between Basic 1 and Basic 2 was statistically significant, [MD = 4.50; $p = .02$; 95% CI (.37, 8.62)], between Basic 1 and Basic 5 was found significant, [MD = 11.03; $p < .001$; 95% CI (6.84, 15.21)], between Basic 1 and Basic 6 reached a significant level, [MD = 22.95; $p < .001$; 95% CI (18.65, 27.25)], between Basic 2 and Basic 5 was found statistically significant, [MD = 6.53; $p < .001$; 95% CI (2.31, 10.75)], and between Basic 2 and Basic 6 was significant, [MD = 18.45; $p < .001$; 95% CI (14.16, 22.74)]

The results also indicate that the mean difference (MD) in teachers’ curriculum implementation between Basic 3 and Basic 5 was statistically significant, [MD = 9.02; $p < .001$; 95% CI (4.94, 13.10)], between Basic 3 and Basic 6 was found significant, [MD = 20.94; $p < .001$; 95% CI (16.78, 25.11)], between Basic 4 and Basic 5 reached a significant level, [MD = 9.16; $p < .001$; 95% CI (5.08, 13.23)], between Basic 4 and Basic 6 was significant, [MD = 21.08; $p < .001$; 95% CI (16.97, 25.20)] and between Basic 5 and Basic 6 the

mean difference was statistically significant, [MD = 11.92 ; $p < .001$; 95% CI (7.78, 16.07)].

The results indicate a difference in teachers' implementation of the standards-based mathematics curriculum in Basic 1, 2, 3, 4, 5 and 6. The results seem to suggest that teachers in Basic 1, Basic 3, Basic 4 and Basic 2 demonstrate moderately higher implementation of the curriculum as compared to teachers in Basic 5 and Basic 6 who seem to demonstrate moderately lower implementation of the standards-based mathematics curriculum.

Regarding the results in Table 67, further follow-up interviews were done to examine what could account for teachers' moderately higher implementation of the standards-based mathematics curriculum in Basic 1, 2, 3, and 4. Also, the follow-up interviews were done to ascertain what could account for teachers' moderately lower implementation of the standards-based mathematics curriculum in Basic 5 and 6. The responses gathered were analysed thematically. Twenty-one (21) teachers' interviews were taken into account due to the saturation of the data. Out of the 21 interviews, 12 teachers were interviewed in Basic 1, 2, 3 and 4, and 9 teachers were interviewed in Basic 5 and 6. 39 codes were generated and grouped into 5 themes for the interviews done in Basic 1, 2, 3 and 4 while 43 codes were generated and grouped into 3 themes for the interviews done in Basic 5 and 6. The themes for Basic 1, 2, 3 and 4 included high monitoring and supervision, teachers' style and mode of implementation, training, support and available resources, teachers' commitment and input, and teachers' knowledge and experience. The themes for Basic 5 and 6 constituted inadequate resources for the implementation,

inadequate training and workshops, and the nature of the curriculum. Below are the thematic presentations of these themes for Basic 1, 2, 3 and 4.

High Monitoring and Supervision

From the interviews, it was observed that teachers in Basic 1, 2, 3 and 4 attributed what could account for their moderately higher implementation regarding the standards-based mathematics curriculum to high monitoring and supervision. Here are a couple of comments from the teachers.

“It is the foundation so teachers are always compelled to start with the learners. At this stage learners need to grasp the basis because of this always they monitor us to see the right things are done” (Excerpt from Teacher 10).

“Teachers in lower grades often receive more training and support in implementing the curriculum effectively. There is also a greater emphasis on monitoring and assessing students' or learners' progress” (Excerpt from Teacher 12).

The teachers' comments seem to suggest that the kind of monitoring and supervision done are some of the issues contributing to their implementation of the curriculum. Teachers' remarks seem to suggest that the monitoring and supervision they have on DL, PLC, learners' learning progress and other activities are high which appears to account for their moderately higher implementation of the curriculum.

Teachers' Teaching Style and Method

From the interviews, it was noticed that teachers in Basic 1, 2, 3 and 4 credited what could account for their moderately higher implementation regarding the standards-based mathematics curriculum to the teaching style and methods they adopted for the implementation. Here are a couple of comments from the teachers.

“I can say I make use of explicit instruction, cooperative learning and flipped classroom. I also engage learners in visual strategies, hands on

learning, strategic questioning and scaffolding learning” (Excerpt from Teacher 5).

“For me is about teachers’ confidence and capabilities about mathematics and its representation. Also, teachers’ knowledge of how to integrate teachings of mathematics through collaborative design” (Excerpt from Teacher 6).

“I am talking about teachers’ own efforts during the teaching and learning process. The kind of pedagogies they apply and how they are able to apply them effectively make a difference” (Excerpt from Teacher 8).

“I attribute it to teachers’ teaching method, assessment method and resources available. At the lower grade levels teachers usually employ learner-centred pedagogies taking into consideration learners’ ages, different backgrounds and a whole lot. The pedagogies are child-friendly and assessment is more on practical activities” (Excerpt from Teacher 16).

“We make use of the DL and PLC. We constantly discuss them and ways we can utilise them for the implementation” (Excerpt from Teacher 19).

“Is due to facilitators’ ways of implementing the curriculum such as the practical use of concrete materials to solve complex problems in groups” (Excerpt from Teacher 21).

The teachers’ comments seem to suggest that the kind of pedagogies they employ such as cooperative learning, strategic questioning, scaffolding, collaborative design, group work, differentiated learning (DL), engagement in the professional learning community (PLC) and other learner-centred pedagogies which are in line with the recommended pedagogies of the Standards-based mathematics curriculum are some of the issues contributing to their implementation of the curriculum. The teachers’ remarks suggest the utilisation of the pedagogies in the curriculum which appears to account for their moderately higher implementation of the curriculum.

Training, Support and Available Resources

From the interviews, it was observed that teachers in Basic 1, 2, 3 and 4 ascribed what could account for their moderately higher implementation regarding the standards-based mathematics curriculum to training, support and

some available resources in the school. Here are a couple of comments from the teachers.

“This is due to teachers’ input and some available mathematics materials. Look at the corner there we have some materials and resources we rely on for our lessons. Even though they are not enough is assisting us in our lessons” (Excerpt from Teacher 8).

“I attribute it to teachers’ teaching method, assessment method, and resources available” (Excerpt from Teacher 16).

“Teachers in lower grades often receive more training and support for implementing the curriculum effectively. There is also a greater emphasis on monitoring and assessing students’ or learners’ progress” (Excerpt from Teacher 12).

The teachers’ comments seem to suggest that the kind of training, support and available resources they have in the various schools are some of the issues contributing to their implementation of the curriculum. The teachers’ remarks seem to imply that the training they are receiving, the support they receive and the resources they have in their schools appear to account for their moderately higher implementation of the curriculum.

Teachers’ Commitment and Input

From the interviews, it was discovered that teachers in Basic 1, 2, 3 and 4 attributed what could account for their moderately higher implementation regarding the standards-based mathematics curriculum to their commitment and input. Here are a couple of comments from the teachers.

“High commitment of teachers and also high commitment of government support, international organisations and donations. I am talking about teachers’ involvement and eagerness to engage learners to benefit from the implementation. This is driving our spirit we always want to see the learners passing” (Excerpt from Teacher 3).

“This is due to teachers’ input and some available mathematics materials. Look at the corner there we have some materials and resources we rely on for our lessons. Even though they are not enough is assisting us in our lessons” (Excerpt from Teacher 8).

“Teachers’ commitment is high despite limited resources. I mean teachers’ strong attachment and the kind of enthusiasm they

demonstrate towards the curriculum's implementation. If you are not committed to something you would not attach any seriousness to it but teachers at this level are very serious about their work and the implementation" (Excerpt from Teacher 9).

The teachers' comments seem to suggest that their commitment and input are some of the issues contributing to their implementation of the standards-based mathematics curriculum. The teachers' remarks seem to imply that their dedication and effort towards the implementation appear to account for their moderately higher implementation of the curriculum.

Teachers' Knowledge and Experience

From the interviews, it was noticed that teachers in Basic 1, 2, 3 and 4 assigned what could account for their moderately higher implementation regarding the standards-based mathematics curriculum to their knowledge and experience they have. Here are a couple of comments from the teachers.

"For me is about teachers' confidence and capabilities about mathematics and its representation. Also, teachers' knowledge of how to integrate teachings of mathematics through collaborative design" (Excerpt from Teacher 6).

"Besides facilitators having a fair knowledge, some of the topics in lower grades are from the previous curriculum" (Excerpt from Teacher 14).

The teachers' comments seem to suggest that the knowledge they possess and experience they have about the previous curriculum are some of the issues contributing to their implementation of the standards-based mathematics curriculum. The teachers' remarks seem to imply that their knowledge about how to integrate the teaching of mathematics and what they know previously from the old curriculum appear to account for their moderately higher implementation of the curriculum. On what could account for teachers' moderately lower implementation of the standards-based mathematics

curriculum in Basic 5 and 6, the themes generated are presented in the sections below.

Inadequate Resources

From the interviews, it was observed that teachers in Basic 5 and 6 attributed what could account for their moderately lower implementation regarding the standards-based mathematics curriculum to inadequate resources.

Here are a couple of comments from the teachers.

“My brother, the resources are not there. How can you implement a new curriculum well with these limited resources? As much as I admit that we need to have more knowledge about the implementation if the resources are there, we can easily implement the curriculum well” (Excerpt from Teacher 1).

“It centres on inadequate teaching and learning materials for the implementation. The standards-based curriculum is good but its implementation should be looked at again. There should be enough TLRs for both the facilitator and the learner if not we won't achieve the purpose of why it was implemented” (Excerpt from Teacher 13).

“To the best of my knowledge, I will attribute it to inadequate teaching and learning materials” (Excerpt from Teacher 17).

“Lack of resource materials and facilities. Not considering the diverse characteristics of learners. Teachers not having enough knowledge of the curriculum” (Excerpt from Teacher 18).

“Resources like textbooks and also some of the topics require much time and training. The DL and PLC are less practiced and I think they could contribute to this” (Excerpt from Teacher 20).

The remarks from the teachers seem to suggest that inadequate resources such as teaching and learning resources and textbooks are some of the issues contributing to moderately lower implementation regarding the standards-based mathematics curriculum as compared to the lower grades. The teachers' comments seem to imply that issues like teaching and learning resources and textbooks are insufficient for facilitators and learners which appear to account for their moderately lower implementation of the curriculum.

Inadequate Training and Workshops

From the interviews, it was noticed that teachers in Basic 5 and 6 credited what could account for their moderately lower implementation regarding the standards-based mathematics curriculum to inadequate training and workshops. Here are a couple of comments from the teachers.

“In-service training for teachers is low. What I am putting across is more training needs to be done. Even for each term if we get three or four or five workshops on the implementation of the new curriculum it won't be bad. This will help us implement the curriculum well” (Excerpt from Teacher 2).

“Is because of low workshops and training. This a new curriculum so there must be a lot of training programmes and workshops for facilitators especially on how to effectively apply the pedagogies recommended in the curriculum. When you have enough workshops as time goes on you get yourself acquainted with how to use the new pedagogies” (Excerpt from Teacher 11).

“Resources like textbooks and also some of the topics require much time and training. The DL and PLC are less practised and I think they could contribute to this” (Excerpt from Teacher 20).

The comments from the teachers seem to suggest that inadequate training and workshops are some of the issues contributing to moderately lower implementation regarding the standards-based mathematics curriculum as compared to the lower grades. The teachers' remarks seem to imply that teachers are not receiving enough training and workshops on the implementation which appears to account for their moderately lower implementation of the curriculum.

Nature of the Curriculum

From the interviews, it was observed that teachers in Basic 5 and 6 ascribed what could account for their moderately lower implementation regarding the standards-based mathematics curriculum to the nature of the curriculum. Here are a couple of comments from the teachers.

“This is because of inadequate time allocated and limited access to resources. Also, some of the things in the upper grades curriculum are not the same as the lower grades for instance some of the topics are more complex when you compare to topics in lower grades with this implementation could not be the same” (Excerpt from Teacher 4).

“To me is curriculum progression, transition challenges and limited resources. When you compare topics in lower grades to topics in upper grades they are not the same. As you move the complexity of the topics increases so definitely it could affect how you are going to implement them. This is what I mean by curriculum progression and transition challenges” (Excerpt from Teacher 15).

The comments from the teachers seem to suggest that the nature of the curriculum in the upper grades in terms of new topics, complex nature of topics and other transition challenges are some of the issues contributing to moderately lower implementation regarding the standards-based mathematics curriculum as compared to the lower grades. The teachers’ remarks seem to imply that issues like new topics, topics being complex in the upper grades and other challenges they encounter as a result of upper grades being higher than the lower grades appear to account for their moderately lower implementation of the curriculum.

Discussion of Results of Research Hypothesis Two (Ho₂)

Hypothesis two (2) sought to examine whether a statistically significant difference exists in teachers’ standards-based mathematics curriculum implementation across their grade levels when the effects of their years of teaching experience, age and gender are controlled for. One-Way ANCOVA results show a statistically significant difference in teachers’ standards-based mathematics curriculum implementation across their grade levels when the effects of their gender and years of teaching experience were controlled for. The effects of both gender and years of experience in teaching as covariates were

found to be insignificant. The results suggest that teachers' curriculum implementation differs across their grade levels.

However, the effects of both gender and years of experience in teaching did not influence teachers' curriculum implementation across the grade levels. This is inconsistent with the findings of Anderson (2020) and Nyagah and Gathumbi (2017), whose studies revealed that teachers' gender significantly influences their curriculum implementation. Also, this current study's finding contradicts those of Dunton and Co. (2019), who found no connection between grade levels and teachers' implementation. This current study's finding implies that teachers' implementation of the standards-based mathematics curriculum varies with regard to the grade levels they teach. It appears that the way teachers implement the curriculum in the various grade levels is different.

The current study's finding indicates a difference in teachers' implementation of the standards-based mathematics curriculum in Basic 1, 2, 3, 4, 5 and 6. The findings seem to suggest that teachers in Basic 1, Basic 3, Basic 4 and Basic 2 demonstrate moderately higher implementation of the curriculum as compared to teachers in Basic 5 and Basic 6 who seem to demonstrate moderately lower implementation of the standards-based mathematics curriculum.

A follow-up interview analysis on what could account for teachers' moderately higher implementation of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4 reveals that teachers ascribed this to high monitoring and supervision, teachers' teaching style and method they employ, training, support and some available resources they have, teachers' commitment and input, and teachers' own knowledge and experience they possess. On what

could account for teachers' moderately lower implementation of the standards-based mathematics curriculum in Basic 5 and 6, teachers assigned this to inadequate resources, inadequate training and workshops and the nature of the curriculum. The current study's findings seem to indicate that regular monitoring and supervision, training and workshops, provision of adequate teaching and learning resources and teachers' knowledge and commitment they have are crucial for the implementation. These seem to be key indicators for teachers' moderately higher implementation of the curriculum in Basic 1, 2, 3 and 4. As found in Isaboke's (2021) study, teachers exposed to training on the competency-based curriculum (CBC) demonstrated an appreciable level of integrating the various core competencies as compared to non-trained teachers. Again, the same study reported a significant link between teachers' training and the curriculum's implementation.

Regarding teachers' moderately lower implementation of the curriculum in Basic 5 and 6, the key indicators seem to be inadequate resources and inadequate training and workshops. As reported by Ayebi-Arthur, Addulai and Korsah (2020), one of the key concerns of teachers regarding the standards-based curriculum implementation is insufficient workshops. Similarly, Mahama (2020) reported teachers' concerns about training. It suggests that these indicators need consideration to enhance teachers' curriculum implementation.

Research Hypothesis Three (H₀₃): There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on implementation of the curriculum, controlling for the effects of years of experience in teaching, age and gender.

This research hypothesis sought to examine whether there are any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on their implementation when the effects of their years of experience in teaching, age and gender are controlled for. A Hierarchical Multiple Linear regression was employed for analysing this data through SPSS versions 22 and 27. Teachers' curriculum implementation score was entered as a continuous dependent variable, teachers' content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK) and contextual knowledge (CtK) were entered as continuous independent variables and teachers' years of experience in teaching and gender were entered as covariates (controlling variables) in the SPSS.

In the SPSS, teachers' years of experience in teaching and gender were entered in Block 1 as covariates, teachers' contextual knowledge (CtK), pedagogical content knowledge (PCK), content knowledge (CK) and pedagogical knowledge (PK) were entered in Block 2, Block 3, Block 4 and Block 5 respectively as continuous independent variables (as predictors) while implementation scores were entered in the dependent box as continuous dependent variable. Age was not included in the SPSS as a covariate since there was a very strong correlation between age and years of experience in teaching

(see Table 44, p. 291). As many scholars (Chavent, Lacaille, Mourer & Olteanu, 2021; Chowdhury & Turin, 2020; Freckleton, 2011) agree that when you have two highly correlated variables, it is prudent to consider removing one of such variables. Hence, because of the high correlation between age and years of experience in teaching, age was dropped as a covariate.

Also, the normality test of the teachers' CK, PK, PCK, CtK and implementation scores were addressed by checking the mean, 5% trimmed mean, median, skewness and kurtosis values (see Table 43, p. 286). The results obtained for the mean, 5% trimmed mean, median, skewness and kurtosis values showed that the teachers' CK, PK, PCK, CtK and implementation scores were approximately normally distributed. Further visual inspection of the regression “standardised residual plot” and the “normal P-P plot of regression standardised residual” was done as shown in Figure 14.

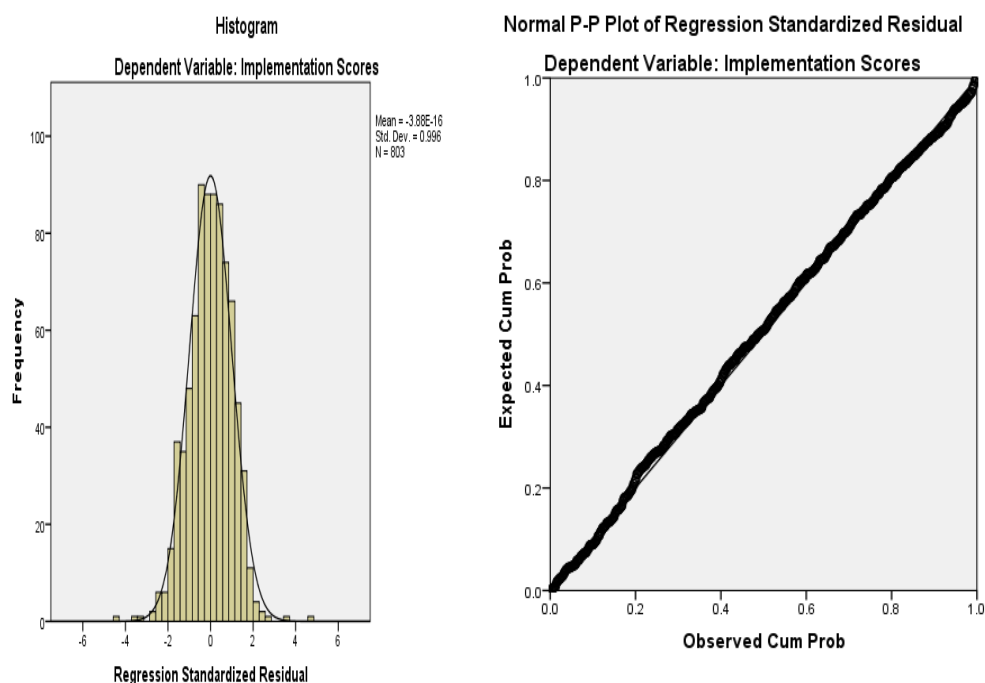


Figure 14: Regression Standardised Residual Plot and Normal P-P Plot

Source: Fieldwork, 2023

From Figure 14, the regression “standardised residual plot” shows that the normality curve of the histogram assumes a bell shape and for the “normal P-P plot of regression standardised residual”, nearly all the points are located on the diagonal line. Hence, the residuals can be described as fairly normally distributed. Again, to address “homoscedasticity”, visual inspection of the scatterplot of the “regression standardised residual” and “regression standardised predicted value” was done as shown in Figure 15.

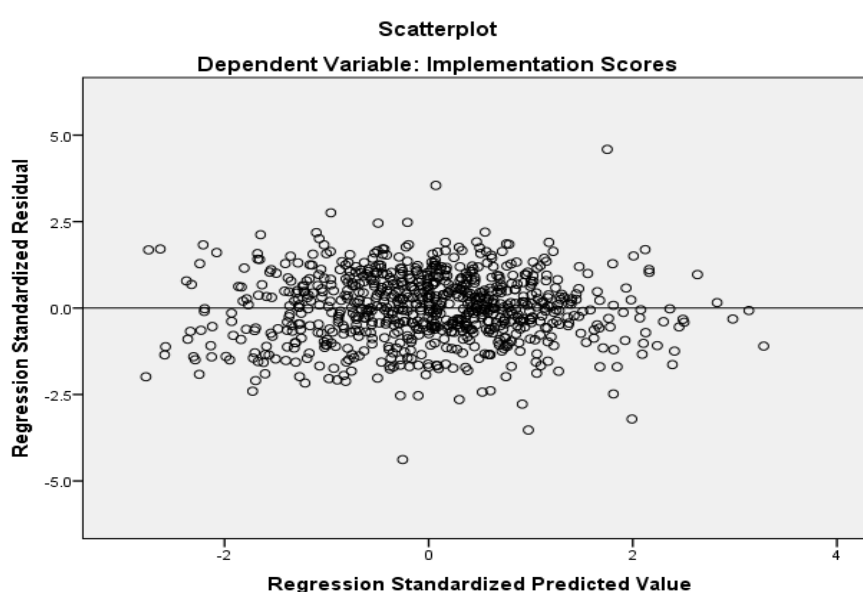


Figure 15: Scatter Plot of Standardised Residual and Standardised Predicted Value

Source: Fieldwork, 2023

From Figure 15, it was observed that the residuals of the scatterplot of the “regression standardised residual” and “regression standardised predicted value” spread uniformly on both sides of the horizontal line at zero (0) point. This suggests that the variance of the residuals is the same across the predictors indicating no violation of the “homoscedasticity” assumption. Further, correlations, tolerance and “Variance Inflation Factor” (VIF) coefficients among teachers’ CK, PK, PCK and CtK as continuous independent variables

were found to address “multicollinearity”. The results obtained for the correlation coefficients are displayed in Table 68, while the coefficients for tolerance and VIF are presented in Table 69.

Table 68: Correlation Among CK, PK, PCK and CtK as Predictors

	CK	PK	PCK	CtK
CK				
PK	.388**			
PCK	.096**	.266**		
CtK	.138**	.196**	.309**	

Source: Fieldwork, 2023; N = 803, **. Correlation is significant at the .01 level (2-tailed) (** $p < .01$)

Looking at the Pearson correlation results between the continuous independent variables from Table 68, it was observed that the correlation between teachers’ CK and PK [$r(801) = .38; p < .001$ (2-tailed)] was not too strong. Between teachers’ CK and PCK [$r(801) = .09; p < .001$ (2-tailed)] was not strong. Similarly, the correlation obtained between teachers’ CK and CtK [$r(801) = .13; p < .001$ (2-tailed)] was not strong. The correlation found between teachers’ PK and PCK was not strong [$r(801) = .26; p < .001$ (2-tailed)]. Between teachers’ PK and CtK [$r(801) = .19; p < .001$ (2-tailed)], the correlation found was not strong. Again, the correlation between teachers’ PCK and CtK [$r(801) = .30; p < .001$ (2-tailed)] was not strong. This suggests that the “multicollinearity assumption” has not been violated. Table 69 presents the results of tolerance and VIF coefficients for CK, PK, PCK and CtK.

Table 69: Tolerance and VIF Coefficients for CK, PK, PCK and CtK

	Tolerance	VIF
CK	.841	1.189
PK	.788	1.269
PCK	.856	1.168
CtK	.882	1.133

Source: Fieldwork, 2023

From Table 69, the results of tolerance and VIF coefficients for CK (tolerance = .84; VIF = 1.18), PK (tolerance = .78; VIF = 1.26), PCK (tolerance = .85; VIF = 1.16) and CtK (tolerance = .88; VIF = 1.13) show that tolerance coefficient for each variable is greater than .10 and not below the threshold of .10 (Tang, Chau, Xu & Liu, 2021; Zaki & Ab Hamid, 2021). Similarly, the VIF coefficient for each variable is less than 10 and not above the threshold of 10 (Tang, Chau, Xu & Liu, 2021; Zaki & Ab Hamid, 2021). This suggests that the multicollinearity assumption is not violated. Therefore, all the continuous independent variables were included in the analysis as predictors. After satisfying these assumptions, the regressions' model summary, ANOVA and coefficient tables were generated. The results for the model summary, ANOVA and coefficient tables are presented in Tables 70, 71 and 72 respectively.

Table 70: The Model Summary for the Hierarchical Multiple Regression

Change Statistics									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.178 ^a	.032	.029	13.587	.032	13.121	2	800	.000
2	.293 ^b	.086	.083	13.208	.054	47.510	1	799	.000
3	.314 ^c	.099	.094	13.126	.012	11.058	1	798	.001
4	.391 ^d	.153	.148	12.732	.054	51.067	1	797	.000
5	.430 ^e	.185	.179	12.495	.032	31.559	1	796	.000

Source: Fieldwork, 2023; a. Predictors: (Constant), years of experience in teaching, teachers' gender; b. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK; c. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK; d. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK, CK; e. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK, CK, PK

From Table 70, the model results show that in Model 1, when years of experience in teaching and gender were included as covariates, both explained 3.2% (R Square; $R^2 = .032$) of the variance in teachers' curriculum implementation (dependent variable) which was statistically significant, $F(2,$

800) = 13.12; $p < .001$. In model 2, when teachers' contextual knowledge (CtK) was included together with years of experience in teaching and gender, the variance explained in teachers' curriculum implementation was 8.6% ($R^2 = .086$). However, when the effects of years of experience in teaching and gender are statistically removed, the teachers' contextual knowledge alone explains 5.4% (R square change; $\Delta R^2 = .054$) of the variance in the teachers' curriculum implementation which was significant statistically, $F(1, 799) = 47.51$; $p < .001$. In model 3, when teachers' pedagogical content knowledge (PCK) was included together with teachers' CtK, years of experience in teaching and gender, the variance explained in teachers' curriculum implementation was 9.9% ($R^2 = .099$). Again, when the effects of years of experience in teaching and gender are statistically removed, the teachers' pedagogical content knowledge alone explains 1.2% ($\Delta R^2 = .012$) of the variance in the teachers' curriculum implementation which was significant statistically, $F(1, 798) = 11.05$; $p = .001$.

In mode 4, when teachers' content knowledge (CK) was included together with teachers' CtK, PCK, years of experience in teaching and gender, the variance explained in teachers' curriculum implementation was 15.3% ($R^2 = .153$). When the effects of years of experience in teaching and gender are statistically removed, the teachers' content knowledge alone explains 5.4% ($\Delta R^2 = .054$) of the variance in the teachers' curriculum implementation which was significant statistically, $F(1, 797) = 51.06$; $p < .001$. In model 5, when teachers' pedagogical knowledge (PK) was included together with teachers' Ctk, PCK, CK, years of experience in teaching and gender, the variance explained in teachers' curriculum implementation was 18.5% ($R^2 = .185$). However, when the effects of years of experience in teaching and gender are

statistically removed, the teachers' pedagogical knowledge alone explains 3.2% ($\Delta R^2 = .032$) of the variance in the teachers' curriculum implementation which was significant statistically, $F(1, 796) = 31.55; p < .001$. Table 71 displays the results of ANOVA for the hierarchical multiple linear regression.

Table 71: ANOVA Results for Hierarchical Multiple Regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4844.071	2	2422.036	13.121	.000 ^b
	Residual	147677.655	800	184.597		
	Total	152521.726	802			
2	Regression	13132.457	3	4377.486	25.092	.000 ^c
	Residual	139389.269	799	174.455		
	Total	152521.726	802			
3	Regression	15037.656	4	3759.414	21.821	.000 ^d
	Residual	137484.070	798	172.286		
	Total	152521.726	802			
4	Regression	23316.392	5	4663.278	28.765	.000 ^e
	Residual	129205.334	797	162.115		
	Total	152521.726	802			
5	Regression	28243.647	6	4707.274	30.150	.000 ^f
	Residual	124278.079	796	156.128		
	Total	152521.726	802			

Source: Fieldwork, 2023; a. Dependent Variable: Implementation Scores, b. Predictors: (Constant), years of experience in teaching, teachers' gender, c. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, d. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK, e. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK, CK, f. Predictors: (Constant), years of experience in teaching, teachers' gender, CtK, PCK, CK, PK

From Table 71, the ANOVA results of the regression show that in model 1, when teachers' years of experience in teaching and gender were included as covariates, the model was statistically significant, $F(2, 800) = 13.12; p < .001$. In model 2, when teachers' contextual knowledge (CtK) was included together with teachers' years of experience in teaching and gender, the model was found significant, $F(3, 799) = 25.09; p < .001$. In model 3, when teachers' pedagogical content knowledge (PCK) was added together with teachers' CtK, years of

experience in teaching and gender, the model was found significant, $F(4, 798) = 21.82; p < .001$. Regarding model 4, when teachers' content knowledge (CK) was included together with teachers' CtK, PCK, years of experience in teaching and gender, the model still maintains its significance, $F(5, 797) = 28.76; p < .001$. In model 5, when teachers' pedagogical knowledge (PK) was included together with teachers' CtK, PCK, CK, years of experience in teaching and gender, the overall model was found statistically significant, $F(6, 796) = 30.15; p < .001$. An inspection of the contribution of each predictor was done. The results are presented in Table 72.

Table 72: Coefficient Results for the Hierarchical Multiple Regression

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta	t		Lower Bound	Upper Bound
1	(Constant)	71.479	1.013		70.542	.000	69.490	73.468
	teachers'							
	gender	-4.842	.965	-.175	-5.019	.000	-6.736	-2.948
	years of experience in teaching	-.090	.067	-.047	-1.337	.182	-.221	.042
2	(Constant)	61.088	1.801		33.922	.000	57.553	64.623
	teachers'							
	gender	-4.292	.941	-.155	-4.559	.000	-6.139	-2.444
	years of experience in teaching	-.059	.065	-.030	-.897	.370	-.187	.070
3	CtK	2.069	.300	.234	6.893	.000	1.480	2.659
	(Constant)	57.124	2.150		26.567	.000	52.903	61.345
	teachers'							
	gender	-4.067	.938	-.147	-4.336	.000	-5.908	-2.226
	years of experience in teaching	-.048	.065	-.025	-.737	.462	-.175	.080
4	CtK	1.756	.313	.199	5.615	.000	1.142	2.371
	PCK	1.072	.322	.118	3.325	.001	.439	1.704
	(Constant)	44.801	2.706		16.555	.000	39.489	50.114
	teachers'							
	gender	-3.549	.913	-.128	-3.889	.000	-5.341	-1.758
	years of experience in teaching	-.025	.063	-.013	-.398	.691	-.149	.099
	CtK	1.521	.305	.172	4.983	.000	.922	2.120
	PCK	.962	.313	.106	3.074	.002	.348	1.577

Table 72, Continued

5	CK	1.363	.191	.237	7.146	.000	.989	1.738
	(Constant)	39.641	2.810		14.106	.000	34.125	45.157
	teachers' gender	-3.329	.896	-.120	-3.713	.000	-5.089	-1.569
	years of experience in teaching	-.012	.062	-.006	-.193	.847	-.134	.110
	CtK	1.378	.301	.156	4.584	.000	.788	1.968
	PCK	.592	.314	.065	1.883	.060	-.025	1.208
	CK	.952	.201	.165	4.737	.000	.558	1.347
	PK	1.142	.203	.202	5.618	.000	.743	1.541

Source: Fieldwork, 2023; a. Dependent Variable: Implementation Scores

From Table 72, an investigation of the coefficients shows that regarding the covariates included in model 1, only gender significantly influenced teachers' curriculum implementation, [$\beta = -.17$; $t = -5.01$; $p < .001$; 95% CI (-6.73, -2.94)] while teachers' years of experience in teaching did not make any significant contribution to their curriculum implementation, [$\beta = -.04$; $t = -1.33$; $p = .18$; 95% CI (-.22, .04)]. In model 2, when teachers' contextual knowledge (CtK) was added, the results show a statistically significant effect on teachers' curriculum implementation, [$\beta = .23$; $t = 6.89$; $p < .001$; 95% CI (1.48, 2.65)]. There was a reduction in the significant effects of teachers' gender on their curriculum implementation, [$\beta = -.15$; $t = 4.55$; $p < .001$; 95% CI (-6.13, -2.44)]. Teachers' years of experience in teaching show no significant effects on teachers' curriculum implementation, [$\beta = -.03$; $t = -.89$; $p < .37$; 95% CI (-.18, .07)].

Regarding model 3, when teachers' pedagogical content knowledge (PCK) was included, the results reveal a statistically significant effect on teachers' curriculum implementation, [$\beta = .11$; $t = 3.32$; $p = .001$; 95% CI (.43, 1.70)]. There was a reduction in the significant effects of teachers' CtK [$\beta = .19$; $t = 5.61$; $p < .001$; 95% CI (1.14, 2.37)] and gender [$\beta = -.14$; $t = -4.33$; $p < .001$; 95% CI (-.28, -.01)].

.001; 95% CI (-5.90, -2.22)] on their curriculum implementation. Teachers' years of experience in teaching had no significant effects on teachers' curriculum implementation, [$\beta = -.02$; $t = -.73$; $p = .46$; 95% CI (-.17, .08)].

Concerning model 4, when teachers' content knowledge (CK) was included, the results show a statistically significant effect on teachers' curriculum implementation, [$\beta = .23$; $t = 7.14$; $p < .001$; 95% CI (.98, 1.73)]. There was a reduction in the significant effects of teachers' Ctk [$\beta = .17$; $t = 4.98$; $p < .001$; 95% CI (.92, 2.12)], PCK [$\beta = .10$; $t = 3.07$; $p = .002$; 95% CI (.34, 1.57)] and gender [$\beta = -.12$; $t = -3.88$; $p < .001$; 95% CI (-5.34, -1.75)] on teachers' curriculum implementation. Teachers' years of experience in teaching had no significant effects on teachers' curriculum implementation, [$\beta = -.01$; $t = -.39$; $p < .69$; 95% CI (-.14, .09)].

Overall, including all the predictors in model 5, the results reveal that teachers' pedagogical knowledge (PK) made the largest statistically significant effects on teachers' curriculum implementation, [$\beta = .20$; $t = 5.61$; $p < .001$; 95% CI (.74, 1.54)], followed by teachers' content knowledge (CK), [$\beta = .16$; $t = 4.73$; $p < .001$; 95% CI (.55, 1.34)], and contextual knowledge (CtK), [$\beta = .15$; $t = 4.58$; $p < .001$; 95% CI (.78, 1.96)], while teachers' pedagogical content knowledge (PCK) had no statistically significant effects on teachers' curriculum implementation, [$\beta = .06$; $t = 1.88$; $p < .06$; 95% CI (-.02, 1.20)]. Concerning the covariates that were controlled for, only teachers' gender made a statistically significant effect on teachers' curriculum implementation, [$\beta = -.12$; $t = -3.71$; $p < .001$; 95% CI (-5.08, -1.56)]. Teachers' years of experience in teaching did not have any significant effects on teachers' curriculum implementation, [$\beta = -.00$; $t = -.19$; $p = .84$; 95% CI (-.13, .11)].

Discussion of Results of Research Hypothesis Three (H03)

Hypothesis three (3) sought to examine whether there are any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on their implementation when the effects of their years of teaching experience, age and gender are controlled for. A hierarchical multiple linear regression was employed. The results revealed that teachers' pedagogical knowledge (PK) had the largest significant effects on teachers' standards-based mathematics curriculum implementation when the effects of their years of experience in teaching and gender were controlled for. The results suggest that teachers' pedagogical knowledge about the curriculum in terms of their knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and knowledge of ICT as a pedagogical tool tend to influence largely their implementation of the standards-based mathematics curriculum. This reaffirms Shulman's (1987) call for strengthening teachers' knowledge of pedagogy in the classroom to complement content and pedagogical content knowledge. Due to the necessity of teachers' pedagogical knowledge, Shulman (1987) re-echoed the need to reinforce pedagogical reasoning and action in classroom activities. This current study's finding is consistent with the findings of Rwigema and Andala (2022), who reported significant effects of teachers' pedagogical knowledge on their competency-based curriculum implementation.

Similarly, the current study's finding is in line with Kisulu, Simatwa and Ndolo (2021) who also reported significant effects of teachers' pedagogical knowledge on their competency-based curriculum implementation. The current

study's finding seems to suggest that teachers' knowledge and appreciation of the various pedagogies for implementing the standards-based mathematics curriculum contribute to their effectiveness regarding the curriculum's implementation. The current study's finding seems to imply that when teachers' knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and knowledge of ICT as a pedagogical tool are strengthened, they could further enhance the curriculum's implementation.

The results also revealed that teachers' content knowledge (CK) had a significant effect on teachers' standards-based mathematics curriculum implementation when the effects of their years of experience in teaching and gender were controlled for. The findings suggest that teachers' content knowledge about the curriculum in terms of knowledge of the organisation and structure of the curriculum, knowledge of expected learning behaviours (learning domains), knowledge of instructional expectations of the curriculum and knowledge of the core competencies tend to greatly influence the curriculum's implementation. This current study's finding is consistent with Kisulu, Simatwa and Ndolo (2021) and Rwigema and Andala (2022) who reported significant effects of teachers' content knowledge on their competency-based curriculum implementation. The current study's findings seem to suggest that teachers' content knowledge of the curriculum in terms of the organisation and structure of the curriculum, expected learning behaviours (learning domains), instructional expectations of the curriculum and the core competencies contributes to their effectiveness regarding the curriculum's implementation. The present study's finding implies that strengthening

teachers' knowledge and appreciation of the curriculum's organisation and structure, expected learning behaviours, instructional expectations and core competencies could enhance the curriculum's implementation.

The results further revealed that teachers' contextual knowledge (CtK) had a significant effect on teachers' curriculum implementation when the effects of their years of experience in teaching and gender were controlled for. The findings suggest that teachers' contextual knowledge about the curriculum in terms of knowledge of learning contexts (classroom, school, community and culture) and knowledge of the learner tends to influence the curriculum's implementation. The current study's finding is consistent with Kosgei (2015) who reported the effects of school-based factors such as knowledge of the classroom on mathematics curriculum implementation. The current study's finding seems to suggest that teachers' contextual knowledge about the curriculum in terms of knowledge of learning contexts (classroom, school, community and culture) and the learner contributes to teachers' effectiveness regarding the curriculum's implementation. The current study's finding implies that enhancing teachers' knowledge and understanding of learning contexts (classroom, school, community and culture) and the learner could improve the curriculum's implementation.

The results pointed out that teachers' pedagogical knowledge (PCK) had no significant effects on teachers' curriculum implementation when the effects of their years of experience in teaching and gender were controlled for. The findings suggest that teachers' pedagogical content knowledge about the curriculum in terms of knowledge of recommended assessment practices and knowledge of learners' learning seems not to contribute significantly to

teachers' implementation of the curriculum. The current study's finding contradicts Gani and Mahjaty (2017) who reported that teachers' knowledge of the standards of evaluation of the "new 2013 curriculum" affected its implementation. The current study's finding seems to suggest that teachers' pedagogical content knowledge about the curriculum in terms of knowledge of recommended assessment practices and knowledge of learners' learning appears to have no effects on teachers' implementation of the curriculum.

Regarding the covariates that were controlled in the study, the findings revealed that only teachers' gender had a significant effect on teachers' standards-based mathematics curriculum implementation, while teachers' years of experience in teaching did not have any significant effects on the curriculum implementation. The study's finding is consistent with Anderson (2020) and Nyagah and Gathumbi (2017), whose studies revealed that teachers' gender significantly influences their curriculum implementation. Similarly, the present study's finding agrees with Owusu and Yiboe (2013) who found no statistically significant effects of teachers' teaching experience on their curriculum implementation. The findings seem to suggest that teachers' gender could influence how they implement the standards-based mathematics curriculum. However, the findings appear to demonstrate that teachers' years of experience in teaching do not influence their implementation of the curriculum.

Research Hypothesis Four (Ho₄): There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on students' academic performance, controlling for the effects of years of experience in teaching, age, gender and students' age.

This research hypothesis sought to examine whether there is any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on students' performance when the effects of their years of experience in teaching, age, gender and students' average age are controlled for. A Hierarchical Multiple Linear regression was employed for analysing this data through SPSS versions 22 and 27. Students' average performance score was entered as a continuous dependent variable, teachers' content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK) and contextual knowledge (CtK) were entered as continuous independent variables and teachers' years of experience in teaching, gender and students' average age were entered as covariates (controlling variables) in the SPSS.

In the SPSS, teachers' years of experience in teaching, gender and students' average age were entered in Block 1 as covariates, teachers' contextual knowledge (CtK), pedagogical content knowledge (PCK), content knowledge (CK) and pedagogical knowledge (PK) were entered in Block 2, Block 3, Block 4 and Block 5 respectively as continuous independent variables (as predictors) while students' average performance scores were entered in the dependent box as continuous dependent variable. Initial correlations among

teachers' gender, years of experience in teaching, age and students' average age were found. The results obtained are presented in Table 73.

Table 73: Correlation Estimates Among the Covariates

	Teachers' Gender	Years of teaching experience	Teachers' Age	Students' Average age
Teachers' Gender				
Years of teaching experience	-.062			
Sig. (2-tailed)	.078			
Teachers' Age	.004	.902**		
Sig. (2-tailed)	.901	.000		
Students' Average age	.315**	-.069	-.040	
Sig. (2-tailed)	.000	.051	.261	

Source: Fieldwork, 2023; N = 803, **. Correlation is significant at the .01 level (2-tailed) (** $p < .01$)

From Table 73, the Pearson correlation (r) and point biserial correlation (r_{pb}) results show that no significant relationship was found between teachers' gender and years of teaching experience [$r_{pb}(801) = -.06$; $p = .07$ (2-tailed)], between teachers' gender and age [$r_{pb}(801) = .00$; $p = .90$ (2-tailed)]. A weak positive correlation was found between teachers' gender and students' average age [$r_{pb}(801) = .31$; $p < .001$ (2-tailed)]. A very strong relationship was found between teachers' years of teaching experience and teachers' age [$r(801) = .90$; $p < .001$ (2-tailed)]. Between teachers' years of experience in teaching and students' average age, the correlation was not significant, [$r(801) = -.06$; $p = .05$ (2-tailed)]. Also, no significant correlation was found between teachers' age and students' average age, [$r(801) = -.04$; $p = .26$ (2-tailed)]. Since teachers' age and years of teaching experience were found to be correlated strongly, teachers' age was not included as a covariate in the analysis. As many scholars (Chavent, Lacaille, Mourer & Olteanu, 2021; Chowdhury & Turin, 2020; Freckleton, 2011) agree that when you have two highly correlated variables, it is prudent to consider removing one of such variables. Hence, because of the

high correlation between teachers' age and years of experience in teaching, teachers' age was dropped as a covariate.

Also, the normality test of the teachers' CK, PK, PCK, CtK and students' average performance scores was addressed by checking the mean, 5% trimmed mean, median, skewness and kurtosis values (see Table 43, p. 286). The results obtained for the mean, 5% trimmed mean, median, skewness and kurtosis values showed that the teachers' CK, PK, PCK, CtK and students' average performance scores were approximately normally distributed. Further, an additional visual examination of the regression "standardised residual plot" and the "normal P-P plot of regression standardised residual" was done as shown in Figure 16.

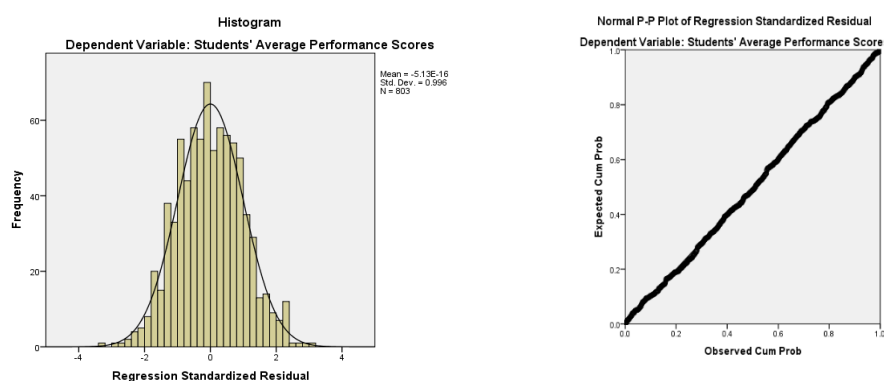


Figure 16: Regression Standardised Residual Plot and Normal P-P Plot

Source: Fieldwork, 2023

From Figure 16, the regression "standardised residual plot" shows that the histogram's normality curve assumes a bell shape and almost every point on the "normal P-P plot of regression standardised residual" is situated on the diagonal line. Hence, the residuals can be described as fairly normally distributed. In addition, to address "homoscedasticity", the scatterplot of the "regression standardised residual" and "regression standardised predicted value" was visually examined as shown in Figure 17.

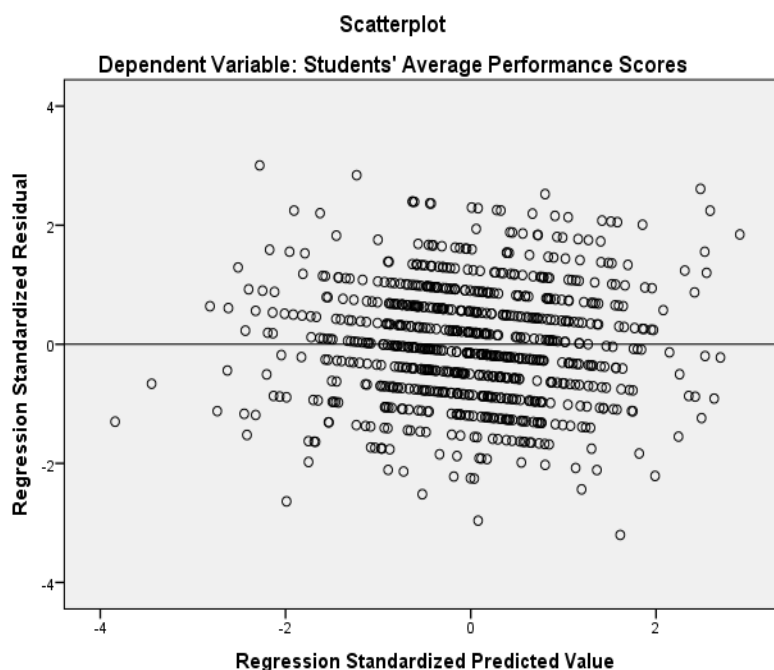


Figure 17: Scatter Plot of Standardised Residual and Standardised Predicted Value

Source: Fieldwork, 2023

From Figure 17, it was observed that the residuals of the scatterplot of the “regression standardised residual” and “regression standardised predicted value” spread uniformly on both sides of the horizontal line at zero (0) point. This implies that the variance of the residuals is the same across the predictors, indicating no violation of the “homoscedasticity” assumption.

Furthermore, correlations, tolerance and “Variance Inflation Factor” (VIF) coefficients among teachers’ CK, PK, PCK and CtK as continuous independent variables were assessed to address “multicollinearity”. The correlation results among the continuous independent variables have already been discussed (see Table 68, p. 349) which reveals that for each pair of continuous independent variables, the correlation found was not strong, suggesting that the “multicollinearity assumption” has not been violated.

Additionally, the coefficients for tolerance and VIF were examined as presented in Table 74.

Table 74: Tolerance and VIF Coefficients for CK, PK, PCK and CtK

	Tolerance	VIF
CK	.829	1.206
PK	.773	1.294
PCK	.856	1.169
CtK	.872	1.146

Source: Fieldwork, 2023

From Table 74, the results of tolerance and VIF coefficients for CK (tolerance = .82; VIF = 1.20), PK (tolerance = .77; VIF = 1.29), PCK (tolerance = .85; VIF = 1.16) and CtK (tolerance = .87; VIF = 1.14) show that the tolerance coefficient for each variable is greater than .10 and not below the threshold of .10 (Tang, Chau, Xu & Liu, 2021; Zaki & Ab Hamid, 2021). Similarly, the VIF coefficient for each variable is less than 10 and not above the threshold of 10 (Tang, Chau, Xu & Liu, 2021; Zaki & Ab Hamid, 2021). This implies that the multicollinearity assumption is not violated. Hence, all the continuous independent variables were included in the analysis as predictors. Following the fulfilment of these presumptions, the model summary, ANOVA, and coefficient tables for the regressions were produced. The results for the model summary, ANOVA and coefficient tables are displayed in Tables 75, 76 and 77 respectively.

Table 75: Model Summary for the Hierarchical Multiple Regression

Model	Change Statistics								
	R		Adjusted		Std. Error	R	F		Sig. F
	R	Square	R Square	R Square	Estimate	Square	Change	df1	df2
1	.089 ^a	.008	.004	.004	2.876	.008	2.128	3	799
2	.123 ^b	.015	.010	.010	2.868	.007	5.794	1	798
3	.124 ^c	.015	.009	.009	2.869	.000	.222	1	797
4	.195 ^d	.038	.031	.031	2.838	.022	18.606	1	796
5	.197 ^e	.039	.030	.030	2.838	.001	.701	1	795

Source: Fieldwork, 2023; a. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender; b. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK; c. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK; d. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK, CK; e. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK, CK, PK

From Table 75, the model results show that in Model 1, when years of experience in teaching, teachers' gender and students' average age were included as covariates, they explained only 0.8% (R square; $R^2 = .008$) of the variance in students' performance (dependent variable) which was statistically insignificant, $F(3, 799) = 2.12$; $p = .09$. In model 2, when teachers' contextual knowledge (CtK) was included together with years of experience in teaching, teachers' gender and students' average age, the variance explained in students' performance was 1.5% ($R^2 = .015$). However, when the effects of years of experience in teaching, teachers' gender and students' average age are statistically removed, the teachers' contextual knowledge alone explains 0.7% (R square change; $\Delta R^2 = .007$) of the variance in the students' performance which was significant statistically, $F(1, 798) = 5.79$; $p = .01$.

In model 3, when teachers' pedagogical content knowledge (PCK) was included together with teachers' CtK, years of experience in teaching, teachers' gender and students' average age, the variance explained in students' performance was 1.5% ($R^2 = .015$). Again, when the effects of years of experience in teaching, teachers' gender and students' average age are statistically removed, the teachers' pedagogical content knowledge accounted for no variance ($\Delta R^2 = .000$) in students' performance which was insignificant statistically, $F(1, 797) = .22$; $p = .63$. In model 4, when teachers' content knowledge (CK) was included together with teachers' CtK, PCK, years of experience in teaching, teachers' gender and students' average age, the variance explained in students' performance was 3.8% ($R^2 = .038$). When the effects of years of experience in teaching, teachers' gender and students' average age are statistically removed, the teachers' content knowledge alone explains 2.2% ($\Delta R^2 = .022$) of the variance in the students' performance which was statistically significant, $F(1, 796) = 18.60$; $p < .001$.

In model 5, when teachers' pedagogical knowledge (PK) was included together with teachers' Ctk, PCK, CK, years of experience in teaching, teachers' gender and students' average age, the variance explained in students' performance was 3.9% ($R^2 = .039$). However, when the effects of years of experience in teaching, teachers' gender and students' average age are statistically removed, the teachers' pedagogical knowledge alone explains 0.1% ($\Delta R^2 = .001$) of the variance in the students' performance which was statistically insignificant, $F(1, 795) = .70$; $p < .40$. Table 76 presents the results of ANOVA for the hierarchical multiple linear regression.

Table 76: ANOVA Results for the Hierarchical Multiple Regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	52.815	3	17.605	2.128	.095 ^b
	Residual	6610.099	799	8.273		
	Total	6662.914	802			
2	Regression	100.466	4	25.117	3.054	.016 ^c
	Residual	6562.448	798	8.224		
	Total	6662.914	802			
3	Regression	102.290	5	20.458	2.485	.030 ^d
	Residual	6560.624	797	8.232		
	Total	6662.914	802			
4	Regression	252.137	6	42.023	5.218	.000 ^e
	Residual	6410.778	796	8.054		
	Total	6662.914	802			
5	Regression	257.781	7	36.826	4.571	.000 ^f
	Residual	6405.133	795	8.057		
	Total	6662.914	802			

Source: Fieldwork, 2023; a. Dependent Variable: Students' average performance scores, b. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, c. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, d. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK, e. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK, CK, f. Predictors: (Constant), students' average age, years of experience in teaching, teachers' gender, CtK, PCK, CK, PK

From Table 76, the ANOVA results of the regression reveal that in model 1 when teachers' years of experience in teaching, gender and students' average age were included as covariates, the model was not statistically significant, $F(3, 799) = 2.12$; $p = .09$. In model 2, when teachers' contextual knowledge (CtK) was included together with teachers' years of experience in teaching, gender and students' average age, the model was found significant, $F(4, 798) = 3.05$; $p = .01$. In model 3, when teachers' pedagogical content knowledge (PCK) was added together with teachers' CtK, years of experience

in teaching, gender and students' average age, the model was statistically significant, $F(5, 797) = 2.48; p < .03$.

Regarding model 4, when teachers' content knowledge (CK) was included together with teachers' CtK, PCK, years of experience in teaching, gender and students' average age, the model maintains its significance, $F(6, 796) = 5.21; p < .001$. In model 5, when teachers' pedagogical knowledge (PK) was included together with teachers' CtK, PCK, CK, years of experience in teaching, gender and students' average age, the overall model was found statistically significant, $F(7, 795) = 4.57; p < .001$. Each predictor's contribution to students' performance was further examined. The results obtained are displayed in Table 77.

Table 77: Coefficient Results for the Hierarchical Multiple Regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	9.332	.538		17.341	.000	8.275	10.388
	teachers' gender	.041	.215	.007	.191	.849	-.381	.463
	years of experience in teaching	-.007	.014	-.017	-.493	.622	-.035	.021
	students' average age	.115	.051	.084	2.248	.025	.015	.215
2	(Constant)	8.338	.677		12.315	.000	7.009	9.666
	teachers' gender	.057	.214	.010	.264	.791	-.364	.478
	years of experience in teaching	-.004	.014	-.011	-.305	.761	-.032	.024
	students' average age	.135	.052	.098	2.616	.009	.034	.236
3	CtK	.159	.066	.086	2.407	.016	.029	.289
	(Constant)	8.197	.740		11.080	.000	6.745	9.650
	teachers' gender	.062	.215	.011	.287	.774	-.360	.483
	years of experience in teaching	-.004	.014	-.010	-.279	.781	-.032	.024
	students' average age	.137	.052	.099	2.640	.008	.035	.238
	CtK	.150	.069	.081	2.168	.030	.014	.285
	PCK	.033	.071	.017	.471	.638	-.105	.172

Table 77, Continued

4	(Constant)	6.066	.883		6.870	.000	4.333	7.799
	teachers' gender	.082	.213	.014	.387	.698	-.335	.500
	years of experience in teaching	.000	.014	.000	-.008	.994	-.028	.028
	students' average age	.177	.052	.129	3.402	.001	.075	.279
	CtK	.125	.069	.068	1.822	.069	-.010	.259
	PCK	.022	.070	.012	.313	.754	-.115	.159
	CK	.186	.043	.155	4.313	.000	.102	.271
5	(Constant)	5.814	.933		6.231	.000	3.982	7.646
	teachers' gender	.083	.213	.014	.389	.697	-.335	.500
	years of experience in teaching	.000	.014	.001	.033	.974	-.027	.028
	students' average age	.183	.053	.133	3.485	.001	.080	.286
	CtK	.121	.069	.066	1.760	.079	-.014	.256
	PCK	.010	.071	.005	.136	.892	-.130	.150
	CK	.173	.046	.144	3.768	.000	.083	.264
	PK	.039	.047	.033	.837	.403	-.053	.131

Source: Fieldwork, 2023; Dependent Variable: Students' Average Performance Scores.

From Table 77, an examination of the coefficients results shows that regarding the covariates included in model 1, only students' average age significantly influenced students' performance, [$\beta = .08$; $t = 2.24$; $p = .02$; 95% CI (.01, .21)], while teacher' years of experience in teaching, [$\beta = -.01$; $t = -.49$; $p = .62$; 95% CI (-.03, .02)] and gender, [$\beta = .00$; $t = .19$; $p = .84$; 95% CI (-.38, .46)] did not make any significant contribution to students' performance. In model 2, when teachers' contextual knowledge (CtK) was added, the results show a statistically significant effect on students' performance, [$\beta = .08$; $t = 2.40$; $p < .01$; 95% CI (.02, .28)]. There was an increase in the significant effects of students' average age on their performance, [$\beta = .09$; $t = 2.61$; $p = .009$; 95% CI (.03, .23)]. Both teachers' years of experience in teaching [$\beta = -.01$; $t = -.30$; $p < .76$; 95% CI (-.03, .02)] and gender [$\beta = .01$; $t = .26$; $p = .79$; 95% CI (-.36, .47)] show no significant effects on students' performance.

Regarding model 3, when teachers' pedagogical content knowledge (PCK) was included, the results revealed no statistically significant effect on students' performance, [$\beta = .01$; $t = .47$; $p = .63$; 95% CI (-.10, .17)]. There was a reduction in the significant effects of teachers' CtK on students' performance [$\beta = .08$; $t = 2.16$; $p = .03$; 95% CI (.01, .28)] while an increase in the significant effects of students' average age on students' performance was observed [$\beta = .09$; $t = 2.64$; $p = .008$; 95% CI (.03, .23)]. Teachers' years of experience in teaching, [$\beta = -.01$; $t = -.27$; $p = .78$; 95% CI (-.03, .02)] and gender, [$\beta = .01$; $t = .28$; $p = .77$; 95% CI (-.36, .48)] had no significant effects on students' performance.

Concerning model 4, when teachers' content knowledge (CK) was included, the results show a statistically significant effect on students' performance, [$\beta = .15$; $t = 4.31$; $p < .001$; 95% CI (.10, .27)]. However, teachers' PCK [$\beta = .01$; $t = .31$; $p = .75$; 95% CI (-.11, .15)] and CtK, [$\beta = .06$; $t = 1.82$; $p = .06$; 95% CI (-.01, .25)] show no significant effects on students' performance. An increase in the significant effects of students' average age on students' performance was observed [$\beta = .12$; $t = 3.40$; $p = .001$; 95% CI (.07, .27)]. Teachers' years of experience in teaching [$\beta = .00$; $t = -.00$; $p = .99$; 95% CI (-.02, .02)] and gender, [$\beta = .01$; $t = .38$; $p = .69$; 95% CI (-.33, .50)] had no significant effects on students' performance.

Overall, including all the predictors in model 5, the results reveal that teachers' pedagogical knowledge (PK) had no statistically significant effects on students' performance, [$\beta = .03$; $t = .83$; $p = .40$; 95% CI (-.05, .13)]. Teachers' CK had a significant effect on students' performance, however, there was a reduction in the effects made, [$\beta = .14$; $t = 3.76$; $p < .001$; 95% CI (.08, .26)].

Teachers' PCK, [$\beta = .00$; $t = .13$; $p = .89$; 95% CI (-.13, .15)] and CtK, [$\beta = .06$; $t = 1.76$; $p = .07$; 95% CI (-.01, .25)] had no significant effects on students' performance. An increase in the significant effects of students' average age on students' performance was observed, [$\beta = .13$; $t = 3.48$; $p = .001$; 95% CI (.08, .28)]. Teachers' years of experience in teaching [$\beta = .00$; $t = .03$; $p = .97$; 95% CI (-.02, .02)] and gender, [$\beta = .01$; $t = .38$; $p = .69$; 95% CI (-.33, .50)] had no significant effects on students' performance.

Discussion of Results of Research Hypothesis Four (H04)

Hypothesis four (4) sought to examine whether there are any statistically significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about the standards-based mathematics curriculum on students' academic performance when the effects of their years of experience in teaching, age, gender and students' age are controlled for. A hierarchical multiple linear regression was employed. The results revealed that teachers' content knowledge (CK) had the largest significant influence on students' performance when the effects of their years of experience in teaching, gender and students' average age were controlled for. The results suggest that teachers' content knowledge about the curriculum in terms of their knowledge of the organisation and structure of the curriculum, knowledge of expected learning behaviours (learning domains), knowledge of instructional expectations of the curriculum and knowledge of the core competencies tends to largely influence students' performance. This emphasises Shulman's (1987) call for strengthening teachers' content knowledge in the classroom to enhance teaching and learning. This current study's finding is consistent with the

findings of Ali, Busch, Qaisrani and Rehman (2020) who reported significant effects of teachers' content knowledge on students' achievement.

Similarly, the current study's finding is in line with Olasehinde-Williams, Yahaya and Owolabi (2018) who also reported significant effects of teachers' content knowledge on students' academic achievement. However, the findings of the current study contradict Nyanjom, Yambo and Ongunya (2021) who found no relationship between teachers' content knowledge and students' academic performance. The present study's finding seems to suggest that teachers' content knowledge about the curriculum in terms of knowledge of the organisation and structure of the curriculum, expected learning behaviours (learning domains), instructional expectations of the curriculum and the core competencies, contributes to students' improvement in learning performance. The current study's finding seems to imply that when teachers' knowledge of the organisation and structure of the curriculum, expected learning behaviours (learning domains), instructional expectations of the curriculum and the core competencies are strengthened, they could improve further students' academic performance.

The results also revealed that teachers' pedagogical knowledge (PK) had no significant effect on students' performance when the effects of their years of experience in teaching, gender and students' average age were controlled for. The findings suggest that teachers' pedagogical knowledge about the curriculum in terms of their knowledge of learner-centred pedagogy, inclusion and equity pedagogy, differentiation and scaffolding pedagogy and knowledge of ICT as a pedagogical tool tends to have no effects on students' performance. This current study's finding is consistent with Michael, Morre and Casocot

(2022) who reported no significant effects of teachers' pedagogical knowledge on students' achievement.

Likewise, the current study's finding agrees with the findings of Olasehinde-Williams, Yahaya and Owolabi (2018) who also found that teachers' pedagogical knowledge had no significant effects on students' academic performance. Again, the present study's finding is in line with Kporyi and Arko (2021) who found no significant relationship between teachers' pedagogical knowledge and students' academic achievement. On the other hand, the current study's finding contradicts the findings of König et al. (2021) who reported a significant effect of teachers' pedagogical competence on students' mathematics achievement. Contrary to the current study's finding, Ali, Busch, Qaisrani and Rehman (2020) reported a significant effect of teachers' pedagogical knowledge on students' achievement. Adeniyi, Ogundele and Odetola (2014) and Yasin (2021) found that teachers' pedagogical knowledge has a significant effect on students' academic achievement. Regarding the current study's finding, it seems to suggest that teachers' pedagogical knowledge and appreciation of the various pedagogies for implementing the standards-based mathematics curriculum tend to have little effect on students' mathematics academic performance.

The results further revealed that teachers' contextual knowledge (Ctk) had no significant effects on students' performance when the effects of their years of experience in teaching, gender and students' average age were controlled for. The findings suggest that teachers' contextual knowledge about the curriculum in terms of knowledge of learning contexts (classroom, school, community and culture) and the learner tends to have no effects on students'

performance. The current study's finding contradicts the findings of Adeniyi, Ogundele and Odetola (2014) who reported a significant effect of teachers' knowledge of the classroom on students' mathematics achievement. The current study's finding seems to suggest that teachers' contextual knowledge about the curriculum in terms of knowledge of learning contexts (classroom, school, community and culture) and the learner tends to have minimal influence on students' performance.

The results showed that teachers' pedagogical content knowledge (PCK) had no significant effects on students' performance when the effects of their years of experience in teaching, gender and students' average age were controlled for. The findings suggest that teachers' pedagogical content knowledge about the curriculum in terms of knowledge of recommended assessment practices and knowledge of learners' learning tends to have no effects on students' performance. The current study's finding contradicts the findings of Nyanjom, Yambo and Ongunya (2020) who found that teachers' assessment competencies significantly influence the achievement of pupils. The current study's finding seems to suggest that teachers' pedagogical content knowledge in terms of knowledge of recommended assessment practices and learners' learning tends to have little influence on students' performance.

Regarding the covariates that were controlled in the study, the findings revealed that only students' age had a significant effect on students' performance while teachers' gender and years of experience in teaching did not have any significant effects on students' performance. The findings seem to suggest that students' age could influence their mathematics academic performance. However, the findings seem to demonstrate that teachers' gender

and years of experience in teaching do not influence students' mathematics performance.

Chapter Summary

The chapter dealt with the results and discussion of the research questions and hypotheses formulated. Research questions 1, 2, 3, 4 and 5 were analysed quantitatively using mean, standard deviations, skewness, and kurtosis. Hypotheses 1 and 2 were tested inferentially using One-Way MANCOVA and One-Way ANCOVA respectively. Also, hypotheses 3 and 4 were tested using Hierarchical multiple linear regression. The qualitative data were presented and discussed thematically alongside the respective research question and hypothesis that showed unique and interesting results.

It was found that teachers demonstrated moderate knowledge in all the sub-dimensions addressing teachers' content and pedagogical knowledge. Overall, teachers' content and pedagogical knowledge in terms of the sub-dimensions were discovered to be moderate. Similarly, it was noticed that teachers demonstrated moderate knowledge in all the sub-dimensions addressing teachers' pedagogical content and contextual knowledge. Overall, teachers' pedagogical content and contextual knowledge were moderate. It was noticed that teachers demonstrated low implementation of ICT, moderately high implementation of recommended assessment practices and the remaining with moderate implementation. Overall, teachers' implementation of the standards-based mathematics curriculum was found to be moderate.

It was also found that the One-Way MANCOVA results showed no statistically significant difference in teachers' knowledge across their academic qualifications and mode of certificate acquisition. In both cases, the effect of

gender influenced teachers' knowledge across academic qualifications and modes of certificate acquisition, whereas years of experience in teaching did not. However, the One-Way MANCOVA results showed a statistically significant difference in teachers' knowledge across their grade levels. The effects of both gender and years of experience in teaching did not influence teachers' knowledge across the grade levels.

Furthermore, it was discovered that the One-Way ANCOVA results showed a statistically significant difference in teachers' curriculum implementation across their grade levels. However, the effects of both gender and years of experience in teaching did not influence teachers' curriculum implementation across the grade levels. It was noticed from the hierarchical multiple linear regression results that teachers' pedagogical knowledge had the largest statistically significant effects on teachers' curriculum implementation, followed by teachers' content knowledge and contextual knowledge, while teachers' pedagogical content knowledge had no statistically significant effects on teachers' curriculum implementation. The effect of gender influenced teachers' curriculum implementation, while years of experience in teaching did not.

Finally, it was found from the hierarchical multiple linear regression results that teachers' content knowledge had a significant effect on students' performance, while teachers' pedagogical, contextual and pedagogical content knowledge had no statistically significant effects on students' performance. The effect of students' age influenced their performance, whereas the effects of teachers' gender and years of experience in teaching did not.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This Chapter presents an overview of the entire study which addresses the purpose of the study, the research questions and the hypotheses formulated to guide the study. The Chapter further provides an overview of the research methods employed and a summary of the key findings derived from the research questions and hypotheses. Subsequently, conclusions are presented based on the findings of the study and recommendations offered concerning the key findings. The last aspect of this Chapter articulates the study's contributions and also offers suggestions for further study regarding new areas that require examination to contribute to the discourse of the study's topic.

Summary

The study examined the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. To appreciate this, the study specifically sought to assess these research questions:

1. What is the content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?
2. What is the pedagogical knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?
3. What is the pedagogical content knowledge of teachers of basic schools about the standards-based mathematics curriculum in the Techiman Municipality?
4. What is the contextual knowledge of basic school teachers about the standards-based mathematics curriculum in the Techiman Municipality?

5. What is the extent of basic school teachers' implementation of the standards-based mathematics curriculum in the Techiman Municipality?

To further understand and appreciate the topic under consideration in detail, the study was guided by these null hypotheses:

Ho₁: There is no significant difference in teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based mathematics curriculum across their academic qualification, mode of certificate acquisition, and grade levels, controlling for the effects of years of experience in teaching, age and gender.

Ho₂: There is no significant difference in teachers' standards-based mathematics curriculum implementation across grade levels, controlling for the effects of years of experience in teaching, age and gender.

Ho₃: There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based curriculum for mathematics on implementation of the curriculum, controlling for the effects of years of experience in teaching, age and gender.

Ho₄: There is no significant effects of teachers' knowledge (content, pedagogical, pedagogical content, contextual knowledge) about standards-based curriculum for mathematics on students' academic performance, controlling for the effects of years of experience in teaching, age, gender and students' age.

In addressing the research questions and the hypotheses formulated, a mixed-method approach, specifically a sequential explanatory design with a follow-up explanation model variant was employed. A census sampling of 942

school teachers in the public primary in the Techiman Municipality was used. 70% (more than half of the students in a class) of students in a class taught by a particular teacher were chosen through a simple random procedure by employing RNG software. The average performance of such students was calculated to represent students' performance in a class and paired with a teacher's knowledge about the standards-based mathematics curriculum. Thirty- three (33) teachers were chosen for an interview, purposively employing an "extreme (or deviant) case sampling. To collect data, teachers' knowledge about standards-based mathematics curriculum questionnaire (TKSBMCQ), students' mathematics performance test (SMPT) and teachers' interview guide (TIG) were employed.

However, the results and discussions of the data gathered were based on the return rate of the TKSBMCQ administered to the teachers ($n = 803$), students' average performance scores from the SMPT ($n = 803$), and subsequent follow-up interviews. Twenty-one (21) teachers' interviews were taken into account due to the saturation of the data. Research questions 1, 2, 3, 4 and 5 were analysed quantitatively using mean, standard deviations, skewness, and kurtosis. Hypotheses 1 and 2 were tested inferentially using One-Way MANCOVA and One-Way ANCOVA respectively. Also, hypotheses 3 and 4 were tested using Hierarchical multiple linear regression. Alongside the respective research question and hypothesis that showed unique and interesting results, the qualitative data were presented and discussed thematically.

Summary of Key Findings

Regarding the results and discussion of the research questions and hypotheses formulated, these key findings were derived:

1. Regarding teachers' content knowledge about the standards-based mathematics curriculum in terms of teachers' knowledge about the organisation and structure of the curriculum, knowledge about expected learning behaviour, knowledge of instructional expectations about the curriculum and knowledge of the core competencies, it was discovered that teachers demonstrated moderate knowledge.
2. Pertaining to teachers' pedagogical knowledge about the standards-based mathematics curriculum in terms of teachers' knowledge of learner-centred pedagogy, knowledge of inclusion and equity pedagogy, knowledge of differentiation and scaffolding pedagogy and knowledge of ICT as a pedagogical tool, it was revealed that teachers demonstrated moderate knowledge.
3. Regarding teachers' pedagogical content knowledge about the standards-based mathematics curriculum in terms of teachers' knowledge of learners' learning and knowledge of recommended assessment practices, it was discovered that teachers demonstrated moderate knowledge.
4. Concerning teachers' contextual knowledge about the curriculum in terms of teachers' knowledge of learning contexts (classroom, school, community and culture) and knowledge of the learner, it was revealed that teachers demonstrated moderate knowledge.
5. Pertaining to teachers' implementation of the standards-based mathematics curriculum in terms of implementing the curriculum's organisation and structure, expected learning behaviours, instructional expectations, core competencies, learner-centred pedagogy, inclusion

and equity pedagogy, differentiation and scaffolding pedagogy, ICT implementation and recommended assessment practices, it was found that teachers' demonstrated low implementation of ICT, while the remaining were moderately high. Overall, teachers' implementation of the standards-based mathematics curriculum was found to be moderate.

6. Regarding hypothesis 1, it was found that the One-Way MANCOVA results showed no statistically significant difference in teachers' knowledge across their academic qualifications and mode of certificate acquisition. In both cases, the effect of gender influenced teachers' knowledge across academic qualifications and modes of certificate acquisition, whereas years of experience in teaching did not. However, the One-Way MANCOVA results showed a statistically significant difference in teachers' knowledge across their grade levels. The effects of both gender and years of experience in teaching did not influence teachers' knowledge across the grade levels.
7. Concerning hypothesis 2, it was discovered that the One-Way ANCOVA results showed a statistically significant difference in teachers' curriculum implementation across their grade levels. However, the effects of both gender and years of experience in teaching did not influence teachers' curriculum implementation across the grade levels.
8. Pertaining to hypothesis 3, it was noticed from the hierarchical multiple linear regression results that teachers' pedagogical knowledge had the largest statistically significant effects on teachers' curriculum implementation, followed by teachers' content knowledge and

contextual knowledge, while teachers' pedagogical content knowledge had no statistically significant effects on teachers' curriculum implementation. The effect of gender influenced teachers' curriculum implementation, while years of experience in teaching did not.

9. Relating to hypothesis 4, it was found from the hierarchical multiple linear regression results that teachers' content knowledge had a significant effect on students' performance, while teachers' pedagogical, contextual and pedagogical content knowledge had no statistically significant effects on students' performance. The effect of students' age influenced their performance, whereas the effects of teachers' gender and years of experience in teaching did not.

Conclusions

Regarding the study's findings, is evident that teachers have a fair appreciation and understanding of the curriculum. However, it may be argued that teachers' level of knowledge about the curriculum is not highly satisfactory which requires continuous training and development of the teachers towards a heightened level of understanding of the curriculum.

It may be argued that teachers' level of implementation of the curriculum is not highly sufficient, which demands regular professional development and in-service training of the teachers to reach a higher level of the curriculum's implementation. Teachers' low implementation of ICT brings to bear that much needs to be done on teachers' part to realise the attainment of 21st century competencies in digital literacy.

Further, concerning the study's findings, it brings to bear that much attention needs to be directed to teachers in upper grades to enhance their

knowledge regarding the standards-based mathematics curriculum. Lower grade teachers also need to be strengthened to increase their knowledge. Issues such as training on the DL and PLC, workshops, teachers' input, commitment and passion need to be strengthened and encouraged. Similarly, it requires that teachers receive a substantial amount of attention in order to improve their implementation of the standards-based mathematics curriculum.

Additionally, per the study's findings, it requires that much focus be directed to strengthening teachers' understanding of the various pedagogies of the curriculum. Equally, teachers' knowledge of what is contained in the curriculum and their contextual appreciation of the curriculum need to be enhanced to efficiently improve the implementation of the curriculum and students' performance.

The study contributed to the literature by providing the level of teachers' knowledge and implementation of the standards-based mathematics curriculum, establishing the influence of teachers' content, pedagogical, pedagogical content and contextual knowledge as well as demographic variables (e.g., gender, age, years of teaching experience) on the implementation and students' performance. It could be said that the study's findings are characterised by being consistent with and contradictory to the literature. This implies that while some of the findings are consistent with what other researchers have found, others do not align with what has been established in the literature on teacher knowledge and curriculum implementation.

Recommendations

In light of the study's findings that were derived from the research questions and the hypotheses formulated, the following are recommended for appropriate actions to be taken.

1. The Municipal Education Directorate and the headteachers should strengthen and intensify training and continuous professional development programmes for teachers towards a heightened level of knowledge and understanding of the curriculum. Teachers are also urged to take initiative and engage themselves in programmes to increase their knowledge of the curriculum.
2. The Municipal Education Directorate and the headteachers should intensify training and workshop programmes for teachers to sufficiently increase their implementation skills to reach a higher level of the curriculum's implementation. Teachers are encouraged to involve themselves in training and workshops to strengthen their skills for the implementation.
3. The Government of Ghana and the Ministry of Education are encouraged to speed up the delivery of ICT resources and tools to schools. Equally, the Municipal Education Directorate and headteachers should initiate a policy framework that serves as a means of liaising with Non-Governmental Agencies (NGOs) to get more ICT resources and tools for schools. Also, the Municipal Education Directorate and headteachers should intensify and deepen training and workshop programmes for ICT integration as a means of enhancing teachers' knowledge and skills in incorporating ICT when implementing the

standards-based mathematics curriculum. Again, the Ghana Education Service should post more ICT-trained teachers in primary schools to enhance ICT integration.

4. The Municipal Education Directorate and headteachers should direct much attention to enhancing upper grades teachers' knowledge about the curriculum by intensifying training and workshops on programmes such as the DL and PLC. Also, the Municipal Education Directorate and headteachers should strengthen and encourage issues such as teachers' input, commitment and passion that lower grade teachers raised for their knowledge about the curriculum. Teachers are also encouraged to involve themselves regularly in training programmes and workshops to increase their knowledge about the curriculum.
5. The Municipal Education Directorate and headteachers should focus a substantial amount of attention on improving upper grades teachers' implementation of the curriculum by intensifying training and workshops on the implementation and providing implementation resources. Equally, the Municipal Education Directorate and headteachers should reinforce, strengthen and encourage issues such as high monitoring and supervision, teachers' commitment and input of teachers for successful implementation of the curriculum.
6. The Municipal Education Directorate and headteachers should engage teachers more in strengthening their understanding of the various pedagogies of the curriculum through continuous training and workshops. Additionally, the Municipal Education Directorate and headteachers should engage teachers more to strengthen teachers'

knowledge of what is contained in the curriculum and their contextual appreciation of the curriculum to improve the implementation and students' performance. Teachers should regularly take part in training programmes about the curriculum to enhance their content understanding.

The Study's Contributions

The study has made a number of contributions in areas relating to knowledge, practice, policy and methods. These are presented below.

Contributions to Area of Knowledge.

These are contributions to the area of knowledge:

1. Teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum do not differ across teachers' academic qualifications and mode of certificate acquisition. However, teachers' gender influences while years of experience in teaching do not.
2. Teachers' content, pedagogical, pedagogical content and contextual knowledge about the standards-based mathematics curriculum differ across grade levels, while teachers' gender and years of experience in teaching do not show any influence.
3. Teachers' standards-based mathematics curriculum implementation differs across their grade levels, while teachers' gender and years of experience in teaching do not show any influence on teachers' implementation across grade levels.
4. Teachers' pedagogical, content and contextual knowledge as well as gender influence teachers' implementation of the curriculum while

teachers' pedagogical content knowledge and years of experience in teaching do not show any influence.

5. Teachers' content knowledge and students' age influence students' performance while teachers' pedagogical, contextual and pedagogical content knowledge as well as teachers' gender and years of experience in teaching do not show any influence.

Contributions to Area of Practice.

Contributions to the area of practice include:

1. The Municipal Education Directorate and the headteachers have been encouraged to strengthen and intensify training, continuous professional development programmes, PLC, DL and workshops for teachers towards a heightened level of knowledge, understanding and implementation of the curriculum to sufficiently increase teachers' implementation skills.
2. Teachers have been urged to take the initiative and engage themselves in training, workshops and other CPD programmes to increase their knowledge and implementation skills of the curriculum to enhance students' performance.
3. The Municipal Education Directorate and headteachers have been encouraged to intensify and deepen training and workshop programmes for ICT integration when implementing the standards-based mathematics curriculum.
4. Through the study's findings, the Municipal Education Directorate and headteachers have been urged to strengthen and encourage teachers'

input, commitment and passion to increase teachers' knowledge about the curriculum and its implementation.

Contributions to Area of Policy

Contributions to the area of policy are:

1. The Ghana Education Service has been urged to post more ICT-trained teachers in primary schools to enhance ICT integration.
2. The Municipal Education Directorate and headteachers have been urged to initiate a policy framework that serves as a means of liaising with Non-Governmental Agencies (NGOs) to get more ICT resources and tools for schools.

Contributions to Area of Methods

Contributions to the area of methods are:

1. More advanced statistical tools such as One-Way MANCOVA and One-Way ANCOVA were employed to establish differences in the dependent variables across the independent variables which offset the shortcomings of less advanced tools.
2. More advanced statistical tool such as Hierarchical multiple linear regression was employed to establish the effects of independent variables on the dependent variables which offset the shortcomings of less advanced tools.
3. Both quantitative and qualitative methods were employed which were more advanced to overcome the inadequacies of the approaches that were already in use in the literature.

Suggestions for Further Research

Since one study could not address all the issues of a research problem, it is highly imperative to draw future researchers' attention to what could be done going forward in an attempt to add to the discourse of the research problem. This present study examined the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. Teachers' knowledge of content, pedagogical, pedagogical content and contextual knowledge about standards-based mathematics curriculum, its influence on implementation and students' performance were assessed. The effects of teachers' gender, age and years of experience in teaching on their knowledge and implementation were assessed. Similarly, the effects of students' age on students' performance were assessed. The study concentrated primarily on public primary school teachers and students in the Techiman Municipality, Bono East Region. Hence, to add to the conversations of the study's topic, additional research is recommended in the following ways:

1. A follow-up study could be carried out to examine the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance in Junior High Schools and Private schools.
2. Further study could be carried out to ascertain the influence of teachers' perceptions on standards-based mathematics curriculum implementation and students' performance.
3. An additional study could be carried out to examine the influence of teachers' beliefs, attitudes and motivation on standards-based mathematics curriculum implementation and students' performance.

4. Further study could be initiated to ascertain the influence of other teachers' demographic characteristics on standards-based mathematics curriculum implementation and students' performance.
5. Additional studies could be carried out that incorporate observation to gain a further picture of how teachers are implementing the standards-based mathematics curriculum.

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APPENDICES

APPENDIX A

Teachers' Knowledge About Standards-Based Mathematics Curriculum Questionnaire (TKSBMCQ)

Dear Sir/Madam,

My name is Mr Blankson Kwaku Adjei, a PhD student pursuing a programme in Curriculum and Teaching at the Department of Business and Social Sciences Education at the University of Cape Coast. I am conducting research on the topic "INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE". The study seeks to examine teachers' knowledge regarding the standards-based mathematics curriculum and how such knowledge influences the implementation and students' performance. I feel that engaging you to participate in this study would provide useful insights. If you accept as a participant, you will be engaged for a duration of 40 to 60 minutes on a day you are contacted within one month period.

SECTION A: Teacher's Background Information

Dear Sir/Madam,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. This section seeks your background information in terms of gender, years of experience in teaching, age in years, academic qualification, mode of certificate acquisition, and the grade level you teach. You are to respond candidly and sincerely by **ticking and writing (where applicable)** the appropriate responses for the statements below.

Information provided will be kept confidential and purely used for this academic purpose.

Gender: Male []

Female []

Please indicate your **years of experience in teaching**.....

Please indicate your **age in years**

Academic qualification: Certificate 'A' []

Diploma []

1st Degree []

Master's Degree []

PhD []

Mode of certificate acquisition: Distance []

Sandwich []

Regular []

Part-time []

Grade Level: Basic 1 []

Basic 2 []

Basic 3 []

Basic 4 []

Basic 5 []

Basic 6 []

SECTION B: Teachers' content knowledge about the standards-based mathematics curriculum

Please respond to all items in this section. You are to indicate your knowledge about the standards-based mathematics curriculum by **ticking** [☐] either **“True”, “False” or “Not Sure”** in the appropriate box for each statement. Your candid and sincere responses would be highly needed.

Knowledge of the organisation and structure of the curriculum				
S/N	Statements	True	False	Not sure
1	The new curriculum is organised into strands, sub-strands, content standards and learning indicators.			
2	An indicator is an outcome that the learner must exhibit each year to meet the content standard expectation.			
3	The annotation, B1. 1. 2. 1. 1 indicates class 1, strand 1, sub-strand 2, content standard 1, and learning indicator 1.			
4	The major strands of the mathematics curriculum are numbers, algebra, geometry and measurement, and data.			
Knowledge of Expected Learning Behaviour (Learning domains)				
5	The expected learning behaviours (learning domains) of the mathematics curriculum constitute knowledge, understanding and application, process skills, attitudes and values.			

6	In the highest level of the learning domains of the mathematics curriculum, the learner is expected to analyse, synthesise, evaluate and create.			
7	It is envisaged that teaching and learning of the new mathematics curriculum should be consistent with the development of skills such as observing, classifying, comparing, communicating, reporting, predicting, and interpreting.			
8	It is envisaged that by teaching and learning the new mathematics curriculum, learners develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness.			
Knowledge of Instructional Expectations about the Curriculum				
9	The focus of the new mathematics curriculum is moving the teaching and learning from the didactic acquisition of knowledge to deep learning.			
10	The new mathematics curriculum emphasises that learners be exposed to situations, tasks and activities that challenge them to construct their own knowledge and understanding.			

11	In teaching and learning the new mathematics curriculum, you are to engage learners to work together as colleagues and generate discourse among themselves.			
12	When teaching the new mathematics curriculum, teachers should act as a guide and facilitators.			
Knowledge of the Core Competencies				
13	The new mathematics curriculum emphasises that learners deepen their learning by developing critical thinking skills to solve real-life problems.			
14	The new mathematics curriculum emphasises that learners create new ideas as well as innovate in solving problems.			
15	In the new curriculum, learners are to be actively engaged in collaborating and sharing their ideas in lessons.			
16	In the new mathematics curriculum, learners are to be engaged in self-awareness and building their self-esteem.			

SECTION C: Teachers' Pedagogical Knowledge about the standards-based mathematics curriculum

Please respond to all items in this section. You are to indicate your knowledge about the standards-based mathematics curriculum by **ticking** [☐] either **“True”**, **“False”** or **“Not Sure”** in the appropriate box for each statement. Your candid and sincere responses would be highly needed.

Knowledge of Learner-Centred Pedagogy				
S/N	Statements	True	False	Not sure
1	In using learner-centred pedagogies, the learner is at the centre of the learning process, offered essential learning experiences and engaged in meaningful hands-on activities.			
2	Learner-centred classroom entails engaging learners in problem-solving activities, inquiry-based activities, investigative activities, project-based work, creative-based work, think-pair-share activities, group work and discussion, cooperative and collaborative activities, case studies, and reflective discussions.			
3	In using learner-centred pedagogy, learners become actively engaged in discussing ideas and looking for answers through the inspiration of the facilitator.			

4	Learner-centred pedagogy aims to make learners take ownership of their learning and become constructors of knowledge.			
Knowledge of Inclusion and Equity Pedagogy				
5	Inclusion and equity pedagogy entails ensuring that daily learning activities are quality and accessible to all learners.			
6	Inclusion and equity of the new mathematics curriculum entail using a variety of approaches that address learners' background, diversity and special needs in the learning process.			
7	Inclusion and equity of the new curriculum entail recognising individual learners' needs, learning experiences, and levels of motivation in planning and delivering a lesson.			
8	Effective use of inclusion and equity in the classroom entails making instruction meaningful by aligning instruction to the learner's interests, abilities, and potential.			
Knowledge of Differentiation and Scaffolding Pedagogy				
9	Differentiation entails accommodating differences in learners' learning styles, interests and readiness, and setting different tasks for learners of different abilities so that			

	each learner in a group has the best possible chance of learning.			
10	Differentiation is by content, process, product, tasks, learning activities, affect, learning environment and assessment.			
11	In scaffolding, we use a variety of instructional techniques to assist/support learners move progressively towards a stronger understanding and ultimately greater independence in the learning process.			
12	Scaffolding entails providing learners with lesson vocabulary, exemplars, and models to increase their understanding.			
Knowledge of ICT as a Pedagogical Tool				
13	Under the new mathematics curriculum, integration of ICT is considered a key tool to enhance deep and independent learning.			
14	Multimedia such as text, audio, graphics, animation, and videos are useful tools to enhance learners' learning.			
15	Using ICT tools in lesson delivery is a way of providing learners access to large quantities of information.			
16	Exposing learners to ICT in the teaching and learning process is a way of increasing their			

	level of motivation, level of competence and ability to apply ICT in later years within and outside of mathematics.			

SECTION D: Teachers' Pedagogical Content Knowledge about the standards-based mathematics curriculum

Please respond to all items in this section. You are to indicate your knowledge about the standards-based mathematics curriculum by **ticking** [☐] either **“True”, “False” or “Not Sure”** in the appropriate box for each statement. Your candid and sincere responses would be highly needed.

Knowledge of Learners' Learning				
S/N	Statements	True	False	Not sure
1	Teachers who understand learners' learning anticipate their conceptions, preconceptions and misconceptions and take time to address them.			
2	Understanding learners' learning entails awareness of learners' errors, learning needs, difficulties, and responses in the teaching and learning process.			
3	Teachers who understand learners' learning are aware of the background experiences learners bring to the classroom.			
4	Teachers who understand learners' learning adjust the pace of instruction to benefit			

	everyone, interpret learners' misunderstandings and design tasks to further their understanding.			
Knowledge of Recommended Assessment Practices				
5	Under the new mathematics curriculum, assessment should entail using multiple and varied strategies to assess learners' learning and should reflect all the learning activities undertaken by the learner.			
6	Under the new mathematics curriculum, assessment entails providing timely and immediate feedback to learners before, during and after instruction.			
7	Assessment entails informing stakeholders such as parents and guardians about the extent to which learners have attained the expected standards of the curriculum.			
8	An authentic way under the new mathematics curriculum is to use learners' portfolios, presentations, projects, observations, and interviews to assess learners' learning.			

SECTION E: Teachers' Contextual Knowledge about the standards-based mathematics curriculum

Please respond to all items in this section. You are to indicate your knowledge about the standards-based mathematics curriculum by **ticking** [✓] “True”, “False” or “Not Sure” in the appropriate box for each statement. Your candid and sincere responses would be highly needed.

Knowledge of learning contexts (classroom, school, community and culture)				
S/N	Statements	True	False	Not sure
1	Valuable information about learners for effective delivery of the new mathematics curriculum is found in learners' communities.			
2	Teaching and learning become meaningful to learners when connected to learners' socio-cultural backgrounds, experiences and practices.			
3	Teaching and learning activities should be situated in learners' real-life contexts and pre-existing knowledge to which they can relate.			
4	A conducive, well-managed and orderly learning classroom atmosphere facilitates effective curriculum delivery.			

Knowledge of the learner				
5	Knowledge of learners' characteristics is a key component for effective instructional practices.			
6	Teachers who are good are aware of their learners' learning styles, motivation, abilities and strengths in the teaching and learning process.			
7	Learners' own emotions and beliefs affect the effective delivery of a curriculum.			
8	Learners' interests, prior experiences and background knowledge are essential for effective curriculum delivery.			

SECTION F: Teachers' implementation of the standards-based mathematics curriculum

Please respond to all items in this section. You are to rate your implementation of the standards-based mathematics curriculum using the Likert scale: **0=Never (N)**; **1=Almost never (AN)**; **2=Occasionally (O)**; **3=Almost every time (AET)**; **4=Every time (ET)**. Please, indicate your response by **ticking [✓]** the appropriate box for each statement. Your candid and sincere responses would be highly needed.

Implementation of Organisation and Structure of the Curriculum						
S/N	Statements	N	AN	O	AET	ET
1	I consider the strands, sub-strands, content standards, indicators, and exemplars before planning my lesson.					
2	I consider the annotations when preparing my lesson.					
Implementation of the Expected Learning Behaviours						
3	I engage learners to analyse, synthesise, evaluate and create new ideas in a mathematics lesson.					
4	I engage learners to develop the skills of observing, classifying, comparing, communicating, reporting, predicting, and interpreting.					
5	I engage learners in mathematics activities/tasks that develop their attitudes and values.					
6	I engage learners to develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness.					

Implementation of the Instructional Expectations of the Curriculum					
7	I engage learners to construct their own knowledge and understanding in mathematics lessons.				
8	I act as a facilitator and engage learners to discuss their ideas in a mathematics lesson.				
9	I expose learners to mathematical situations, tasks and activities that challenge them in deep and profound mathematics learning.				
10	I make learners work together as colleagues and generate discourse among themselves in a mathematics lesson.				
Implementation of the Core Competencies					
11	I engage learners in problem-solving and problem-posing activities to develop their critical thinking skills.				
12	I engage learners in mathematical inquiry to make them creative and innovative.				
13	I engage learners actively to participate, communicate and collaborate in sharing their ideas in a mathematics lesson.				

14	I engage learners in self-awareness and self-esteem in a mathematics lesson.					
Implementation of Learner-Centred Pedagogy						
15	I engage learners in meaningful hands-on activities during a mathematics lesson.					
16	I engage learners in problem-solving activities, inquiry-based activities, investigative-based activities, project-based activities, discovery activities/work, group work and group discussion, creative-based activities/work, think-pair-share activities, cooperative and collaborative activities, case studies, and reflective discussions in a mathematics lesson.					
17	I involve learners actively in a mathematics lesson, working in groups, solving and looking for answers on their own rather than providing the answers.					
18	I make learners take ownership of their learning in mathematics lessons to construct their own knowledge.					

Implementation of Inclusion and Equity Pedagogy					
19	I give access to all learners and ensure that mathematics learning activities are accessible to all learners.				
20	I engage learners using a variety of approaches to address learners' diversity, special needs, abilities and potentials in a mathematics lesson.				
21	I accommodate learners' learning styles, interests and readiness during mathematics instruction to make all learners have the best possible chance of learning.				
22	I engage learners through their learning needs, learning experiences, background, and levels of motivation in planning and delivering a mathematics lesson.				
Implementation of Differentiation and Scaffolding Pedagogy					
23	I break down content, tasks and mathematics learning activities for learners' different abilities to ensure that they are accessible and adequately benefit every learner.				
24	I allow learners to respond to tasks at different levels and move progressively				

	towards a stronger understanding and greater independence.					
25	I provide learners with mathematical vocabulary and exemplars, offer a simplified version of mathematics lessons and gradually increase the sophistication over time.					
26	I use multiple ways to engage learners to enhance their understanding.					
Implementation of ICT						
27	I make use of ICT to enhance learners' deep and independent learning in mathematics lessons.					
28	I support learners using multimedia such as audio, graphics, animation, and videos during a mathematics lesson.					
29	I use ICT to support learners in accessing information online in a mathematics lesson.					
30	I make learners organise mathematics activities using ICT to enhance their level of creativity and motivation.					
Implementation of Recommended Assessment Practices						
31	I make use of learners' portfolios, project work, presentations,					

	observations, interviews, and diaries to assess learners' achievement of the curriculum standards and other learning progress.					
32	I engage learners individually and in groups to assess their attainment of the core competencies, 4Rs, attitudes, values and other learning outcomes.					
33	I assess learners' learning at all stages of the lesson to cover all learning activities undertaken by the learner.					
34	I make use of feedback from learners' assessments to improve their learning.					

APPENDIX B**Teachers' Interview Guide (TIG)**

The purpose of this interview is to probe certain unique quantitative results I obtained about the standards-based mathematics curriculum. In the first phase, when I collected data from you and analysed it, I saw certain findings that I needed to interview you on your perspectives regarding what could account for these unique results to have a comprehensive understanding. Please, feel free to share your views. You may skip any question you feel you are unwilling to answer or uncomfortable with. Your candid and sincere responses are highly welcome. Any information you give would be protected, kept secret and confidential.

Name of Teacher (Pseudonym):

Name of School:

Date of Interview:

Grade Level:

Interview Duration: From: To:

1. In your view, what could account for the low implementation of ICT regarding the standards-based mathematics curriculum?
2. In your view, what could account for the moderately higher knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4?
3. In your view, what could account for the moderately higher implementation of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4?
4. In your view, what could account for the moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6?

5. In your view, what could account for the moderately lower implementation of the standards-based mathematics curriculum in Basic 5 and 6?
6. Please let me know if you have any other information or opinions.

APPENDIX C

Students' Mathematics Performance Test (SMPT)

Class 1 (Basic 1)

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [✓] or **writing** where applicable

1. Please, indicate your age

SECTION B

INSTRUCTIONS

Please, **tick** [✓] the appropriate box to indicate your response using **True, False or Not Sure**

S/N	Statements	True	False	Not sure
1	Abena has 10 mangoes and receives 4 more mangoes. In all, Abena has 14 mangoes.			
2	Kwaku has 15 pencils. He gave 6 to Ama. Kwaku has 9 pencils left.			
3	Tina harvested 10 tubers of yams. Her brothers ate 10 tubers of her yams. Tina has no tubers of yam.			

4	Afia brought 6 red pencils and 7 blue Pencils to school. Afia has 13 pencils.			
5	Nana Yaw gave GH¢ 1 to Kwasi and GH¢ 2 to Fusena. Nana Yaw has given GH¢ 3 out.			
6	16 is greater than ($>$) 15.			
7	12 is less than ($<$) 18.			
8	11 is equal to ($=$) 11.			
9	0 is less than ($<$) 1.			
10	One-quarter is an example of a fraction.			
11	One-tenth is an example of a fraction.			
12	One-half is an example of a fraction.			
13	7- 4 will produce the same result as 6-3.			
14	Anane has 7 bananas, 4 mangoes and 3 apples. Anane has 14 fruits altogether.			
15	The sum of 12 and 13 is 25.			
16	The difference between 17 and 16 is 1.			
17	A circle is a 2D shape.			
18	A rectangle is a 2D shape.			
19	A square is a 2D shape.			
20	All the sides of a square are the same.			

Students' Mathematics Performance Test (SMPT)**Class 2 (Basic 2)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [☐] or **writing** where applicable

1. Please, indicate your age

SECTION B**INSTRUCTIONS**

Please, **tick** [☐] the appropriate box to indicate your response using **True, False or Not Sure**

S/N	Statements	True	False	Not sure
1	The missing terms of the pattern, 3, ..., 9, ..., 15, ..., 21, ..., 27 are 6, 12, 18, and 24.			
2	The rule for this pattern, 4, 8, 12, 16, 20, ..., is "add 4".			

3	Afia has 10 mangoes, and she gave 4 of the mangoes to Ama. Six (6) mangoes will be left over for Afia.			
4	Alima has 7 red erasers, 3 blue erasers, and her mother bought 6 more green erasers for her. Alima will have 16 erasers altogether.			
5	One-half ($\frac{1}{2}$) is bigger than one-quarter ($\frac{1}{4}$)			
6	Mr Gyasi bought a slice of meat for GH¢ 10.00, garden eggs for GH¢ 5.00, and pepper for GH¢ 3.00. Mr Gyasi paid GH¢ 18.00 for the items.			
7	GH¢ 10.00 is double of GH¢ 5.00			
8	The rule for this pattern, 12, 9, 6, ..., ..., is “subtract 3”.			
9	The value of multiplying 3 by 2 is the same as multiplying 2 by 3.			
10	The value of the missing number in this equation, $12 \times \dots = 24$ is 2.			
11	Ten of 50 pesewas will be GH¢ 5.00.			
12	The value of adding 13 to 17 is 30.			
13	When you take 8 oranges from 19 oranges, the remaining oranges will be 11.			
14	All the sides of a square are the same.			

15	One-third is represented as $\frac{1}{3}$.			
16	One whole is represented as 1			
17	The sum of GHC 5.00, GHC 10.00, and GHC 1.00 will be GHC 16.00.			
18	A triangle and a square are examples of 2D shapes.			
19	A rectangle and a circle are examples of 2D shapes.			
20	Ama came to school with GHC 10.00 and used GHC 5.00 for food, GHC 3.00 for lorry fare, and GHC 1.00 for water. Ama still has some amount of money left for her.			

Students' Mathematics Performance Test (SMPT)**Class 3 (Basic 3)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [☐] or **writing** where applicable

1. Please, indicate your age

SECTION B**INSTRUCTIONS**

Please, **tick** [☐] the appropriate box to indicate your response using **True, False or Not Sure**

S/N	Statements	True	False	Not sure
1	The fractions $\frac{1}{3}$ and $\frac{2}{6}$ are the same.			
2	The numeral for the quarter is $\frac{1}{4}$.			
3	The fraction $\frac{1}{9}$ is one-ninth.			
4	Ten of the 50GP coins are the same as GHC5.00.			

5	If Kofi buys a book at GH¢3.50 with GH¢10.00, he will get GH¢6.50 as change.			
6	If Ama buys a toffee at 40Gp with GH¢1.00, she will get 60Gp as a change.			
7	If Mr Danso buys two footballs each at GH¢8.00, he will pay GH¢16.00.			
8	If GH¢20.00 is given to 4 girls to share equally, each will get GH¢5.00.			
9	A rectangle has 4 sides.			
10	A regular shape has straight sides.			
11	The difference between 431 and 289 is 142.			
12	The sum of 2 and 97 is the same as the sum of 60 and 39.			
13	When you divide 45 by 3 your result will be 15.			
14	If you divide zero by any number you get zero.			
15	The product of 6 and 5 is 30.			
16	When you multiply zero by any number your result will be zero.			
17	The product of 0 and 100 is less than the product of 1 and 2.			
18	The value of 4 in 428 is 400.			
19	The value of 3 in 539 is 30.			
20	The place value of 2 in 287 is hundreds.			

Students' Mathematics Performance Test (SMPT)**Class 4 (Basic 4)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [$\sqrt{\quad}$] or **writing** where applicable

1. Please, indicate your age

SECTION B**INSTRUCTIONS**

Please, **tick** [$\sqrt{\quad}$] the appropriate box to indicate your response using **True**,

False or Not Sure

S/N	Statements	True	False	Not sure
1	The square of 6 is 36.			
2	The next square number of the sequence, 1, 4, 9, 16, ... is 25.			
3	The product of 5 and 6 is 30.			
4	20 is a double of 10.			

5	Kofi, Amo, and Mensah were given GH¢3 each for school for 1 week. For the whole week, each receives GH¢15.00.			
6	Yeboah has GH¢ 35.00. She gave GH¢ 9.00 to a friend and shared the remaining with her two daughters. Each received GH¢13. 00.			
7	Mr Amadu shared 60 oranges among his 4 children equally. Each received 15 oranges.			
8	4 boxes; Box 1, Box 2, Box 3 and Box 4 contain 12 apples, 20 apples, 35 apples and 48 apples respectively. Box 4 has 36 apples more than Box 1.			
9	The perimeter of a square is 72cm. Each side is 18cm.			
10	If the perimeter of a rectangle is 34cm and has length of 10cm, its width is 7cm.			
11	A square and a rectangle are 2D shapes.			
12	A circle and a triangle are 2D shapes.			
13	The simplest form of $\frac{3}{15}$ is $\frac{1}{5}$.			
14	The fractions; $\frac{2}{4}$ and $\frac{3}{6}$ have the same value.			
15	The sum of 314, 415 and 298 is 1027.			
16	The nearest thousand of 45132 is 46000.			

17	4, 8, 12, 16, 20, 24, 28, and 32 show skip counting in 4s.			
18	The next four patterns of 3, 6, 9, ..., ..., ..., ..., are 12, 15, 18, and 21.			
19	The value of x in $x + 30 = 97$ is 67.			
20	Mr Sumala gave $\frac{1}{8}$ of his land to his eldest son, $\frac{3}{8}$ to his wife and $\frac{2}{8}$ to his mother. Mr Sumala still retains a section of the land.			

Students' Mathematics Performance Test (SMPT)**Class 5 (Basic 5)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [$\sqrt{\quad}$] or **writing** where applicable

1. Please, indicate your age

SECTION B**INSTRUCTIONS**

Please, **tick** [$\sqrt{\quad}$] the appropriate box to indicate your response using **True**,

False or Not Sure

S/N	Statements	True	False	Not sure
1	Ama received $\frac{1}{4}$ of GH¢ 500.00, whilst Kofi received $\frac{3}{4}$ of the same amount. Kofi received GH¢ 250.00 more than Ama.			
2	Mr Anokye had a discount of 20% on a shoe which sells at GH¢ 650. 00. Mr Anokye paid GH¢520.00.			

3	A man pays GHC 154.00 for his electricity bill, GHC 35.00 for his water bill, and GHC 200.00 for other expenses. If he receives GHC 800.00 as his monthly salary, he is left with GHC 411.00.			
4	The value of $-2 + (-6)$ is -8.			
5	Mr Nsowah gave $\frac{1}{5}$ of his land to his wife and $\frac{2}{5}$ of the same land to his sons. He still retains $\frac{2}{5}$ of the land.			
6	The fractions; $\frac{2}{5}$ and $\frac{4}{10}$ have the same value.			
7	The sum of $\frac{1}{6}$, $\frac{2}{6}$ and $\frac{3}{6}$ is 1.			
8	The perimeter of a rectangle is 120cm, and its length is 40cm, hence, its width will be 20cm.			
9	The simplest form of the expression, $-7m + 3m$ is $-4m$.			
10	The value of “t” in $t = 2(5f - 3n)$ when $f = 4$ and $n = 3$ is 22.			
11	The decimal 0.9 is the same as $\frac{9}{10}$.			
12	The nearest hundred thousand of 458412356 is 458400000.			

13	20% of GH¢ 250. 00 is GH¢ 50.00			
14	The next four numbers of the pattern, 125, 142, 159, ..., ..., ..., ..., are 176, 193, 210, and 227.			
15	The value of the expression $7k + d$ is 25 when $k = 3$ and $d = 4$.			
16	The product of the Highest Common Factor of 4 and 6, and 8 and 10 is 4.			
17	A cube and a cone are examples of 3D shapes.			
18	A cylinder and a cuboid are examples of 3D shapes.			
19	The nearest tenths of 678.473 is 678.5			
20	Mr Ampoma went to Techiman market with GH¢ 165.00 for week 1 and bought 3 pieces of cloth for GH¢ 16.00 each, and a slice of meat for GH¢ 25.00. He returned home with GH¢ 92.00.			

Students' Mathematics Performance Test (SMPT)**Class 6 (Basic 6)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

Please indicate your response by **ticking** [✓] or **writing** where applicable

1. Please, indicate your age

SECTION B**INSTRUCTIONS**

Please, **tick** [✓] the appropriate box to indicate your response using **True, False or Not Sure.**

S/N	Statements	True	False	Not sure
1	The number name for forty-three thousand, eight hundred and seventy-two is 43,872.			
2	The value of 5 in 456, 321 is 50,000.			
3	The place value of 4 in 643571 is ten-thousands			
4	The value of 28941 is the same as $20,000 + 8000 + 900 + 40 + 1$.			
5	The nearest hundred of 5781 is 5800.			
6	The sum of the highest factors of 10 and 6 is 16.			

7	The least common multiple of 5 and 6 is 30.			
8	The first five prime numbers are 2, 3, 5, 7 and 11.			
9	When 120 apples are shared among 8 children each will receive 15 apples.			
10	If Mr Adjei's car takes 5 hours to consume 50 litres of diesel, in 10 hours his car will consume 100 litres of diesel.			
11	The value of y in the relation $y=2x+5$ will be 13 when $x=4$.			
12	The next three numbers of the number pattern 2, 4, 8, 14, ..., ..., ..., will be 22, 32 and 44.			
13	The algebraic expression for 6 bananas plus 5 tomatoes will be $6b + 5t$.			
14	A cylinder has no vertices.			
15	A cuboid has 6 faces.			
16	The area of a square will be 25cm^2 when one side is 5cm.			
17	The ratio of 4 pens and 20 books will be 1: 5.			
18	If a school has 6 classrooms and each class has 20 pupils, the total number of pupils in the school will be 120.			
19	If a goat has 4 legs, 20 goats will have 80 legs.			
20	The prime factors of 15 are 3 and 5.			

APPENDIX D**Face and Content Validity Form for Teachers' Knowledge About****Standards-Based Mathematics Curriculum Questionnaire (TKSBMCQ)****Subject: Request for Input for Face and Content Validity**

I am a student at the University of Cape Coast pursuing a PhD programme in Curriculum and Teaching. As part of the data collection for my Thesis, I need to undertake the face and content validity of my instruments. I sincerely request that you go through my items for the questionnaire using the instructions provided below.

INSTRUCTION: Tick [☐] either 'YES' or 'NO' where applicable using the following criteria: appropriateness of grammar, clarity and unambiguity of the item, correct spelling of words, correct structuring of sentences, appropriateness of difficulty level of the item and relevance/appropriateness of each item for the construct of the questionnaire.

YES means you agree that each item is in line with the above criteria.

NO means not in agreement that each item is in line with the above criteria.

TEACHERS' QUESTIONNAIRE**SECTION A: Teacher's Background Information**

Gender: Male [☐] Yes [☐] No [☐]

Female [☐]

Please indicate your **years of teaching experience** Yes [☐] No [☐]

Please indicate your **age in years** Yes [☐] No [☐]

Academic qualification: Certificate 'A' [] Yes [] No []

Diploma []

1st Degree []

Master's Degree []

PhD []

Mode of certificate acquisition: Distance [] Yes [] No []

Sandwich []

Regular []

Part-time []

Grade Level: Lower Primary Level [] Yes [] No []

Upper Primary Level []

SECTION B: Teachers' content knowledge about the standards-based mathematics curriculum

Knowledge of the organisation and structure of the curriculum			
S/N	Statements	Yes	No
1	The new curriculum is organised into strands, sub-strands, content standards and learning indicators.		
2	An indicator is an outcome that the learner must exhibit each year to meet the content standard expectation.		
3	The annotation, B1. 1. 2. 1. 1 indicates class 1, strand 1, sub-strand 2, content standard 1, and learning indicator 1.		
4	The major strands of the mathematics curriculum are numbers, algebra, geometry and measurement, and data.		
Knowledge of Expected Learning Behaviour (Learning domains)			

5	The expected learning behaviours (learning domains) of the mathematics curriculum constitute knowledge, understanding and application, process skills, attitudes and values.		
6	In the highest level of the learning domains of the mathematics curriculum, the learner is expected to analyse, synthesise, evaluate and create.		
7	It is envisaged that teaching and learning of the new mathematics curriculum should be consistent with the development of skills such as observing, classifying, comparing, communicating, reporting, predicting, and interpreting.		
8	It is envisaged that by teaching and learning the new mathematics curriculum, learners develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness.		
Knowledge of Instructional Expectations about the Curriculum			
9	The focus of the new mathematics is moving the teaching and learning from the didactic acquisition of knowledge to deep learning.		
10	The new mathematics curriculum emphasises that learners be exposed to situations, tasks and activities that challenge them to construct their own knowledge and understanding.		

11	In teaching and learning the new mathematics curriculum, you are to engage learners to work together as colleagues and generate discourse among themselves.		
12	When teaching the new mathematics curriculum, teachers should act as a guide and facilitators.		
Knowledge of the Core Competencies			
13	The new mathematics curriculum emphasises that learners deepen their learning by developing critical thinking skills to solve real-life problems.		
14	The new mathematics curriculum emphasises that learners create new ideas as well as innovate in solving problems.		
16	In the new curriculum, learners are to be actively engaged in collaborating and sharing their ideas in lessons.		
16	In the new mathematics curriculum, learners are to be engaged in self-awareness and building their self-esteem.		

SECTION C: Teachers' Pedagogical Knowledge about the standards-based mathematics curriculum

Knowledge of learner-centred pedagogy			
S/N	Statements	Yes	No
1	In using learner-centred pedagogies, the learner is at the centre of the learning process, offered essential learning experiences and engaged in meaningful hands-on activities.		

2	Learner-centred classroom entails engaging learners in problem-solving activities, inquiry-based activities, investigative activities, project-based work, creative-based work, think-pair-share activities, group work and discussion, cooperative and collaborative activities, case studies, and reflective discussions.		
3	In using learner-centred pedagogy, learners become actively engaged in discussing ideas and looking for answers through the inspiration of the facilitator.		
4	Learner-centred pedagogy aims to make learners take ownership of their learning and become constructors of knowledge.		
Knowledge of Inclusion and Equity pedagogy			
5	Inclusion and equity pedagogy entails ensuring that daily learning activities are quality and accessible to all learners.		
6	Inclusion and equity of the new mathematics curriculum entail using a variety of approaches that address learners' background, diversity and special needs in the learning process.		

7	Inclusion and equity of the new curriculum entail recognising individual learners' needs, learning experiences, and levels of motivation in planning and delivering a lesson.		
8	Effective use of inclusion and equity in the classroom entails making instruction meaningful by aligning instruction to the learner's interests, abilities, and potential.		
Knowledge of Differentiation and Scaffolding Pedagogy			
9	Differentiation entails accommodating differences in learners' learning styles, interests and readiness, and setting different tasks for learners of different abilities so that each learner in a group has the best possible chance of learning.		
10	Differentiation could be by content, process, product, tasks, learning activities, affect, learning environment and assessment.		
11	In scaffolding, we use a variety of instructional techniques to assist/support learners move progressively towards a stronger understanding and ultimately greater independence in the learning process.		

12	Scaffolding entails providing learners with lesson vocabulary, exemplars, and models to increase their understanding.		
Knowledge of ICT as a Pedagogical Tool			
13	Under the new mathematics curriculum, integration of ICT is considered a key tool to enhance deep and independent learning.		
14	Multimedia such as text, audio, graphics, animation, and videos are useful tools to enhance learners' learning.		
15	Using ICT tools in lesson delivery is a way of providing learners access to large quantities of information.		
16	Exposing learners to ICT in the teaching and learning process is a way of increasing their level of motivation, level of competence and ability to apply ICT in later years within and outside of mathematics.		

SECTION D: Teachers' Pedagogical Content Knowledge about the standards-based mathematics curriculum

Knowledge of Learners' Learning			
S/N	Statements	Yes	No
1	Teachers who understand learners' learning anticipate their conceptions, preconceptions and misconceptions and take time to address them.		
2	Understanding learners' learning entails awareness of learners' errors, learning needs, difficulties, and responses in the teaching and learning process.		
3	Teachers who understand learners' learning are aware of the background experiences learners bring to the classroom.		
4	Teachers who understand learners' learning adjust the pace of instruction to benefit everyone, interpret learners' misunderstandings and design tasks to further their understanding.		
Knowledge of Recommended Assessment Practices			
5	Under the new mathematics curriculum, assessment should entail using multiple and varied strategies to assess learners' learning and should reflect all the learning activities undertaken by the learner.		
6	Under the new mathematics curriculum, assessment entails providing timely and immediate feedback to learners before, during and after instruction.		

7	Assessment entails informing stakeholders such as parents and guardians about the extent to which learners have attained the expected standards of the curriculum.		
8	An authentic way under the new mathematics curriculum is to use learners' portfolios, presentations, projects, observations and interviews to assess learners' learning.		

SECTION E: Teachers' Contextual Knowledge about the standards-based mathematics curriculum

Knowledge of learning contexts (classroom, school, community and culture)			
S/N	Statements	Yes	No
1	Valuable information about learners for effective delivery of the new mathematics curriculum is found in learners' communities.		
2	Teaching and learning become meaningful to learners when connected to learners' socio-cultural backgrounds, experiences and practices.		
3	Teaching and learning activities should be situated in learners' real-life contexts and pre-existing knowledge to which they can relate.		

4	A conducive, well managed and orderly learning classroom atmosphere facilitates effective curriculum delivery.		
Knowledge of the learner			
5	Knowledge of learners' characteristics is a key component for effective instructional practices.		
6	Teachers who are good are aware of their learners' learning styles, motivation, abilities and strengths in the teaching and learning process.		
7	Learners' own emotions and beliefs affect the effective delivery of a curriculum.		
8	Learners' interests, prior experiences and background knowledge are essential for effective curriculum delivery.		

SECTION F: Teachers' implementation of the standards-based mathematics curriculum

Implementation of Organisation and Structure of the Curriculum			
S/N	Statements	Yes	No
1	I consider the strands, sub-strands, content standards, indicators, and exemplars before planning my lesson.		
2	I consider the annotations when preparing my lesson.		
Implementation of the Expected Learning Behaviours			
3	I engage learners to analyse, synthesise, evaluate and create new ideas in a mathematics lesson.		

4	I engage learners to develop the skills of observing, classifying, comparing, communicating, reporting, predicting, and interpreting.		
5	I engage learners in mathematics activities/tasks that develop their attitudes and values.		
6	I engage learners to develop commitment, tolerance, patriotism, respect for evidence, cooperation, responsibility, and environmental awareness.		
Implementation of the Instructional Expectations of the Curriculum			
7	I engage learners to construct their own knowledge and understanding in mathematics lessons.		
8	I act as a facilitator and engage learners to discuss their ideas in a mathematics lesson.		
9	I expose learners to mathematical situations, tasks and activities that challenge them in deep and profound mathematics learning.		
10	I make learners work together as colleagues and generate discourse among themselves in a mathematics lesson.		
Implementation of the Core Competencies			
11	I engage learners in problem-solving and problem-posing activities to develop their critical thinking skills.		
12	I engage learners in mathematical inquiry to make them creative and innovative.		

13	I engage learners actively to participate, communicate and collaborate in sharing their ideas in a mathematics lesson.		
14	I engage learners in self-awareness and self-esteem in a mathematics lesson.		
Implementation of Learner-Centred Pedagogy			
15	I engage learners in meaningful hands-on activities during a mathematics lesson.		
16	I engage learners in problem-solving activities, inquiry-based activities, investigative-based activities, project-based activities, discovery activities/work, group work and group discussion, creative-based activities/work, think-pair-share activities, cooperative and collaborative activities, case studies, and reflective discussions in a mathematics lesson.		
17	I involve learners actively in a mathematics lesson, working in groups, solving and looking for answers on their own rather than providing the answers.		
18	I make learners take ownership of their learning in mathematics lessons to construct their own knowledge.		
Implementation of Inclusion and Equity pedagogy			
19	I give access to all learners and ensure that mathematics learning activities are accessible to all learners.		

20	I engage learners using a variety of approaches to address learners' diversity, special needs, abilities and potentials in a mathematics lesson.		
21	I accommodate learners' learning styles, interests and readiness during mathematics instruction to make all learners have the best possible chance of learning.		
22	I engage learners through their learning needs, learning experiences, background, and levels of motivation in planning and delivering a mathematics lesson.		
Implementation of Differentiation and Scaffolding Pedagogy			
23	I break down content, tasks and mathematics learning activities for learners' different abilities to ensure that they are accessible and adequately benefit every learner.		
24	I allow learners to respond to tasks at different levels and move progressively towards a stronger understanding and greater independence.		
25	I provide learners with mathematical vocabulary and exemplars, offer a simplified version of mathematics lessons and gradually increase the sophistication over time.		
26	I use multiple ways to engage learners to enhance their understanding.		
Implementation of ICT			
27	I make use of ICT to enhance learners' deep and independent learning in mathematics lessons.		

28	I support learners using multimedia such as audio, graphics, animation, and videos during a mathematics lesson.		
29	I use ICT to support learners in accessing information online in a mathematics lesson.		
30	I make learners organise mathematics activities using ICT to enhance their level of creativity and motivation.		
Implementation of Recommended Assessment Practices			
31	I make use of learners' portfolios, project work, presentations, observations, interviews, and diaries to assess learners' achievement of the curriculum standards and other learning progress.		
32	I engage learners individually and in groups to assess their attainment of the core competencies, 4Rs, attitudes, values and other learning outcomes.		
33	I assess learners' learning at all stages of the lesson to cover all learning activities undertaken by the learner.		
34	I make use of feedback from learners' assessments to improve their learning.		

APPENDIX E**Face and Content Validity Form for Students' Mathematics Performance
Test (SMPT)****Subject: Request for Input for Face and Content Validity**

I am a student at the University of Cape Coast pursuing a PhD programme in Curriculum and Teaching. As part of the data collection for my Thesis, I need to undertake the face and content validity of my instruments. I sincerely request that you go through my items for the test using the instructions provided below.

INSTRUCTION: Tick [☐] either 'YES' or 'NO' where applicable using the following criteria: appropriateness of grammar, clarity and unambiguity of the item, correct spelling of words, correct structuring of sentences, appropriateness of difficulty level of the item and relevance/appropriateness of each item of the Test.

YES means you agree that each item is in line with the above criteria.

NO means not in agreement that each item is in line with the above criteria.

Students' Mathematics Performance Test (SMPT)**Class 1 (Basic 1)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age.....

Yes [☐] No [☐]

SECTION B

S/N	Statements	Yes	No
1	Abena has 10 mangoes and receives 4 more mangoes. In all, Abena has 14 mangoes.	☐	☐
2	Kwaku has 15 pencils. He gave 6 to Ama. Kwaku has 9 pencils left.	☐	☐
3	Tina harvested 10 tubers of yams. Her brothers ate 10 tubers of her yams. Tina has no tubers of yam.	☐	☐
4	Afia brought 6 red pencils and 7 blue Pencils to school. Afia has 13 pencils.	☐	☐
5	Nana Yaw gave GH¢ 1 to Kwasi and GH¢ 2 to Fusena. Nana Yaw has given GH¢ 3 out.	☐	☐
6	16 is greater than ($>$) 15.	☐	☐
7	12 is less than ($<$) 18.	☐	☐

8	11 is equal to (=) 11.		
9	0 is less than (<) 1.		
10	One-quarter is an example of a fraction.		
11	One-tenth is an example of a fraction.		
12	One-half is an example of a fraction.		
13	7- 4 will produce the same result as 6-3.		
14	Anane has 7 bananas, 4 mangoes and 3 apples. Anane has 14 fruits altogether.		
15	The sum of 12 and 13 is 25.		
16	The difference between 17 and 16 is 1.		
17	A circle is a 2D shape.		
18	A rectangle is a 2D shape.		
19	A square is a 2D shape.		
20	All the sides of a square are the same.		

Students' Mathematics Performance Test (SMPT)**Class 2 (Basic 2)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age..... Yes [☐] No [☐]

SECTION B

S/N	Statements	Yes	No
1	The missing terms of the pattern, 3, ..., 9, ... 15, ..., 21, ..., 27 are 6, 12, 18, and 24.		
2	The rule for this pattern, 4, 8, 12, 16, 20, ..., ..., ..., is "add 4".		
3	Afia has 10 mangoes, and she gave 4 of the mangoes to Ama. Six (6) mangoes will be left over for Afia.		
4	Alima has 7 red erasers, 3 blue erasers, and her mother bought 6 more green erasers for her. Alima will have 16 erasers altogether.		
5	One-half ($\frac{1}{2}$) is bigger than one-quarter ($\frac{1}{4}$)		

6	Mr Gyasi bought a slice of meat for GH¢ 10.00, garden eggs for GH¢ 5.00, and pepper for GH¢ 3.00. Mr Gyasi paid GH¢ 18.00 for the items		
7	GH¢ 10.00 is double of GH¢ 5.00.		
8	The rule for this pattern, 12, 9, 6, ..., ..., ..., is “subtract 3”.		
9	The value of multiplying 3 by 2 is the same as multiplying 2 by 3.		
10	The value of the missing number in this equation, $12 \times \dots = 24$ is 2.		
11	Ten of 50 pesewas will be GH¢ 5.00.		
12	The value of adding 13 to 17 is 30.		
13	When you take 8 oranges from 19 oranges, the remaining oranges will be 11.		
14	All the sides of a square are the same.		
15	One-third is represented as $\frac{1}{3}$.		
16	One whole is represented as 1		
17	The sum of GH¢ 5.00, GH¢ 10.00, and GH¢ 1.00 will be GH¢ 16.00.		
18	A triangle and a square are examples of 2D shapes.		
19	A rectangle and a circle are examples of 2D shapes.		
20	Ama came to school with GH¢ 10.00 and used GH¢ 5.00 for food, GH¢ 3.00 for lorry fare, and GH¢ 1.00 for water. Ama still has some amount of money left for her.		

Students' Mathematics Performance Test (SMPT)**Class 3 (Basic 3)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age.....

Yes [] No []

SECTION B

S/N	Statements	Yes	No
1	The fractions $\frac{1}{3}$ and $\frac{2}{6}$ are the same.		
2	The numeral for the quarter is $\frac{1}{4}$.		
3	The fraction $\frac{1}{9}$ is one-ninth.		
4	Ten of the 50GP coins are the same as GHC5.00.		
5	If Kofi buys a book at GHC3.50 with GHC10.00, he will get GHC6.50 as change.		
6	If Ama buys a toffee at 40Gp with GHC1.00, she will get 60Gp as a change.		
7	If Mr Danso buys two footballs each at GHC8.00, he will pay GHC16.00.		

8	If GH¢20.00 is given to 4 girls to share equally, each will get GH¢5.00.		
9	A rectangle has 4 sides.		
10	A regular shape has straight sides.		
11	The difference between 431 and 289 is 142.		
12	The sum of 2 and 97 is the same as the sum of 60 and 39.		
13	When you divide 45 by 3 your result will be 15.		
14	If you divide zero by any number you get zero.		
15	The product of 6 and 5 is 30.		
16	When you multiply zero by any number your result will be zero.		
17	The product of 0 and 100 is less than the product of 1 and 2.		
18	The value of 4 in 428 is 400.		
19	The value of 3 in 539 is 30.		
20	The place value of 2 in 287 is hundreds.		

Students' Mathematics Performance Test (SMPT)**Class 4 (Basic 4)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age Yes [☐] No [☐]

SECTION B

S/N	Statements	Yes	No
1	The square of 6 is 36.		
2	The next square number of the sequence, 1, 4, 9, 16, ... is 25.		
3	The product of 5 and 6 is 30.		
4	20 is a double of 10.		
5	Kofi, Amo, and Mensah were given GH¢3 each for school for 1 week. For the whole week, each receives GH¢15.00.		
6	Yeboah has GH¢ 35.00. She gave GH¢ 9.00 to a friend and shared the remaining with her two daughters. Each received GH¢13. 00.		
7	Mr Amadu shared 60 oranges among his 4 children equally. Each received 15 oranges.		

8	4 boxes; Box 1, Box 2, Box 3 and Box 4 contain 12 apples, 20 apples, 35 apples and 48 apples respectively. Box 4 has 36 apples more than Box 1.		
9	The perimeter of a square is 72cm. Each side is 18cm.		
10	If the perimeter of a rectangle is 34cm and has length of 10cm, its width is 7cm.		
11	A square and a rectangle are 2D shapes.		
12	A circle and a triangle are 2D shapes.		
13	The simplest form of $\frac{3}{15}$ is $\frac{1}{5}$.		
14	The fractions; $\frac{2}{4}$ and $\frac{3}{6}$ have the same value.		
15	The sum of 314, 415 and 298 is 1027.		
16	The nearest thousand of 45132 is 46000.		
17	4, 8, 12, 16, 20, 24, 28, and 32 show skip counting in 4s.		
18	The next four patterns of 3, 6, 9, ..., ..., ..., ... are 12, 15, 18, and 21.		
19	The value of x in $x + 30 = 97$ is 67.		
20	Mr Sumala gave $\frac{1}{8}$ of his land to his eldest son, $\frac{3}{8}$ to his wife and $\frac{2}{8}$ to his mother. Mr Sumala still retains a section of the land.		

Students' Mathematics Performance Test (SMPT)**Class 5 (Basic 5)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age

Yes [] No []

SECTION B

S/N	Statements	Yes	No
1	Ama received $\frac{1}{4}$ of GH¢ 500.00, whilst Kofi received $\frac{3}{4}$ of the same amount. Kofi received GH¢ 250.00 more than Ama.		
2	Mr Anokye had a discount of 20% on a shoe which sells at GH¢ 650. 00. Mr Anokye paid GH¢520.00.		
3	A man pays GH¢ 154.00 for his electricity bill, GH¢ 35.00 for his water bill, and GH¢ 200.00 for other expenses. If he receives GH¢ 800.00 as his monthly salary, he is left with GH¢ 411.00.		
4	The value of $-2 + (-6)$ is -8.		
5	Mr Nsowah gave $\frac{1}{5}$ of his land to his wife and $\frac{2}{5}$ of the same land to his sons. He still retains $\frac{2}{5}$ of the land.		

6	The fractions; $\frac{2}{5}$ and $\frac{4}{10}$ have the same value.		
7	The sum of $\frac{1}{6}$, $\frac{2}{6}$ and $\frac{3}{6}$ is 1.		
8	The perimeter of a rectangle is 120cm, and its length is 40cm, hence, its width will be 20cm.		
9	The simplest form of the expression, $-7m + 3m$ is $-4m$.		
10	The value of “t” in $t = 2(5f - 3n)$ when $f = 4$ and $n = 3$ is 22.		
11	The decimal 0.9 is the same as $\frac{9}{10}$.		
12	The nearest hundred thousand of 458412356 is 458400000.		
13	20% of GH¢ 250. 00 is GH¢ 50.00.		
14	The next four numbers of the pattern, 125, 142, 159, ..., ..., ..., are 176, 193, 210, and 227.		
15	The value of the expression $7k + d$ is 25 when $k = 3$ and $d = 4$.		
16	The product of the Highest Common Factor of 4 and 6, and 8 and 10 is 4.		
17	A cube and a cone are examples of 3D shapes.		
18	A cylinder and a cuboid are examples of 3D shapes.		
19	The nearest tenths of 678.473 is 678.5		
20	Mr Ampoma went to Techiman market with GH¢ 165.00 for week 1 and bought 3 pieces of cloth for GH¢ 16.00 each, and a slice of meat for GH¢ 25.00. He returned home with GH¢ 92.00.		

Students' Mathematics Performance Test (SMPT)**Class 6 (Basic 6)**

Dear Student,

The data is purely for academic purposes to enable the researcher to ascertain the influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance. You are to respond candidly and sincerely to the statements below. Information provided would be kept confidential and purely used for this academic purpose.

SECTION A

1. Please, indicate your age Yes [☐] No [☐]

SECTION B

S/N	Statements	Yes	No
1	The number name for forty-three thousand, eight hundred and seventy-two is 43,872.		
2	The value of 5 in 456, 321 is 50,000		
3	The place value of 4 in 643571 is ten-thousands.		
4	The value of 28941 is the same as $20,000 + 8000 + 900 + 40 + 1$.		
5	The nearest hundred of 5781 is 5800.		
6	The sum of the highest factors of 10 and 6 is 16.		
7	The least common multiple of 5 and 6 is 30.		
8	The first five prime numbers are 2, 3, 5, 7 and 11.		
9	When 120 apples are shared among 8 children each will receive 15 apples.		

10	If Mr Adjei's car takes 5 hours to consume 50 litres of diesel, in 10 hours his car will consume 100 litres of diesel.		
11	The value of y in the relation $y=2x+5$ will be 13 when $x=4$.		
12	The next three numbers of the number pattern 2, 4, 8, 14, ..., ..., ..., will be 22, 32 and 44.		
13	The algebraic expression for 6 bananas plus 5 tomatoes will be $6b + 5t$.		
14	A cylinder has no vertices.		
15	A cuboid has 6 faces.		
16	The area of a square will be 25cm^2 when one side is 5cm.		
17	The ratio of 4 pens and 20 books will be 1: 5.		
18	If a school has 6 classrooms and each class has 20 pupils, the total number of pupils in the school will be 120.		
19	If a goat has 4 legs, 20 goats will have 80 legs.		
20	The prime factors of 15 are 3 and 5.		

APPENDIX F**Face and Content Validity Form for Teachers' Interview Guide (TIG)****Subject: Request for Input for Face and Content Validity**

I am a student at the University of Cape Coast pursuing a PhD programme in Curriculum and Teaching. As part of the data collection for my Thesis, I need to undertake the face and content validity of my instruments. The purpose of this interview is to probe certain unique quantitative results I obtained about the standards-based mathematics curriculum in the first phase of the quantitative analysis. I sincerely request that you go through my items for the Teachers' Interview Guide using the instructions provided below.

INSTRUCTION: Tick [☐] either 'YES' or 'NO' where applicable using the following criteria: appropriateness of grammar, clarity and unambiguity of the item, correct spelling of words, correct structuring of sentences, appropriateness of difficulty level of the item and relevance/appropriateness of the item for the interview for each item of the interview guide.

YES means you agree that each item is in line with the above criteria.

NO means not in agreement that each item is in line with the above criteria.

Name of Teacher (Pseudonym):

Name of School:

Date of Interview:

Grade Level:

Interview Duration: From: To:

1. In your view, what could account for the low implementation of ICT regarding the standards-based mathematics curriculum?

Yes [] No []

2. In your view, what could account for the moderately higher knowledge of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4?

Yes [] No []

3. In your view, what could account for the moderately higher implementation of the standards-based mathematics curriculum in Basic 1, 2, 3 and 4?

Yes [] No []

4. In your view, what could account for the moderately lower knowledge of the standards-based mathematics curriculum in Basic 5 and 6?

Yes [] No []

5. In your view, what could account for the moderately lower implementation of the standards-based mathematics curriculum in Basic 5 and 6?

Yes [] No []

6. Please let me know if you have any other information or opinions.

Yes [] No []

APPENDIX G

Application Letter for Ethical Clearance

Blankson Kwaku Adjei

Department of Business and Social Sciences Education

University of Cape Coast

Cape Coast, Ghana.

3rd July, 2023.

The Director,

Institutional Review Board

University of Cape Coast

Cape Coast.

Dear Sir/Madam,

REQUEST FOR ETHICAL CLEARANCE

I respectfully write to your highly esteemed office to request ethical clearance to help me collect data for my doctoral thesis. The research topic under study is “INFLUENCE OF TEACHERS’ KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS’ PERFORMANCE”.

Attached are the thesis proposal and other relevant documents for your attention.

I hope my request will meet your usual consideration and approval.

Thank you.

Yours faithfully



Blankson Kwaku Adjei

Tel: 0248163404/0506376002

APPENDIX H

Supervisor's Consent Letter

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF HUMANITIES & SOCIAL SCIENCES EDUCATION
DEPARTMENT OF BUSINESS & SOCIAL SCIENCES EDUCATION

Telephone: +233 209408788
EXT. (268), Direct: 35411.
Telegrams & Cables: University, Cape Coast.
Email: dbase@ucc.edu.gh
Our Ref: DoBSSE/37/V.2/
Your Ref:



UNIVERSITY POST OFFICE
CAPE COAST, GHANA

DATE: 3rd July, 2023

The Chairperson
Institutional Review Board
University of Cape Coast
Cape Coast

Dear Sir,

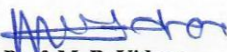
LETTER OF CONSENT

As the supervisor, I write to formally inform you that I give my consent for Mr. Blankson Kwaku Adjei to apply for clearance from IRB to enable him undertake data collection for his PhD. thesis titled **"INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE"**.

I am counting on your cooperation.

Thank you.

Yours faithfully,



Prof. M. B. Yidana
Supervisor

APPENDIX I

Acceptance Letter from the Department

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF HUMANITIES & SOCIAL SCIENCES EDUCATION
DEPARTMENT OF BUSINESS & SOCIAL SCIENCES EDUCATION

Telephone: +233 209408788

EXT. (268), Direct: 35411.

Telegrams & Cables: University, Cape Coast.

Email: dbase@ucc.edu.gh

Our Ref: DoBSSE/37/V.2/68

Your Ref:

UNIVERSITY POST OFFICE
CAPE COAST, GHANADATE: 3rd July, 2023

The Chairperson
Institutional Review Board
University of Cape Coast
Cape Coast

Dear Sir,

ACCEPTANCE OF PROPOSAL

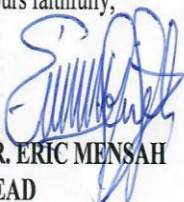
We formally bring to your notice that the Department is satisfied with the research proposal of Mr. Blankson Kwaku Adjei, and has accordingly given the said candidate the permission to apply for ethical clearance from IRB in order to enable him to undertake data collection.

He is working on the Research Topic: "INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE."

We count on your usual cooperation.

Thank you.

Yours faithfully,


DR. ERIC MENSAH
HEAD

APPENDIX J

Ethical Clearance Letter

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309

E-MAIL: irb@ucc.edu.gh

OUR REF: IRB/C3/Vol.1/0489

YOUR REF:

OMB NO: 0990-0279

IORG #: IORG0011497

15TH NOVEMBER, 2023

Mr Blankson Kwaku Adjei
Department of Business and Social Sciences Education
University of Cape Coast

Dear Mr Adjei

ETHICAL CLEARANCE – ID (UCCIRB/CES/2023/121)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Influence of Teachers' Knowledge on Standards-Based Mathematics Curriculum Implementation and Students' Performance**. This approval is valid from 15th November 2023 to 14th November 2024. You may apply for an extension of ethical approval if the study lasts for more than 12 months.

Please note that any modification to the project must first receive renewal clearance from the UCCIRB before its implementation. You are required to submit a periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us about this protocol.

Yours faithful

Kofi F. Amuquandoh
Ag. Administrator

SECRET
FOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

APPENDIX K

Application Letter for an Introductory Letter

BLANKSON KWAKU ADJEI

DEPT OF BUSINESS AND SOCIAL SCIENCES EDU

UNIVERSITY OF CAPE COAST

16TH NOVEMBER, 2023.

THE MUNICIPAL DIRECTOR

GHANA EDUCATION SERVICE

TECHIMAN, BONO EAST

Dear Sir,

REQUEST FOR AN INTRODUCTORY LETTER

I humbly write to your esteemed institution to request an introductory letter to assist me in collecting data for my doctoral thesis from the public primary teachers and students in Basic 1 to Basic 6 in the Municipality on the research topic "Influence of teachers' knowledge on standards-based mathematics curriculum implementation and students' performance".

Attached are the ethical clearance letter and other relevant documents for your attention.

I hope my request will be considered.

Thank you.

Yours Faithfully



Blankson Kwaku Adjei

Email: adjeikwakubblankson@gmail.com

Tel: 0248163404/0506376002

APPENDIX L

Introductory Letter

GHANA EDUCATION SERVICE
TECHIMAN MUNICIPALITY

In case of reply the number and date of this letter should be quoted

Tel. No: 0352522628
Email techmuedu2012@gmail.com

My Ref. No. GES/TEM/27/VOL. 12/23
Your Ref. No.:



Republic of Ghana

Post Office Box 12,
Techiman, B/E,
Ghana.

16th November, 2023ALL HEADS OF PUBLIC PRIMARY SCHOOLS
TECHIMANINTRODUCTORY LETTER
BLANKSON KWAKU ADJEI (MR)

I write to introduce to you Mr. Blankson Kwaku Adjei, a student of the Department of Business and Social Sciences Education, University of Cape Coast.

Mr. Blankson kwaku Adjei is working on a doctoral thesis titled "**Influence of Teachers' Knowledge on Standards-Based Mathematics Curriculum Implementation and Students' Performance**" in public primary schools in the Techiman Municipality.

You are kindly requested to provide him with the necessary support to enable him successfully complete his research work.

Thank you.

JOHN K. AMISSAH (MR.)
MUNICIPAL DIRECTOR

Cc: MR. BLANKSON KWAKU ADJEI
UCC, CAPE COAST

APPENDIX M

Informed Consent Form for Teachers



INFORMED CONSENT FORM FOR ADULT

PART I: INFORMATION SHEET

Title: INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE

Principal Investigator: BLANKSON KWAKU ADJEI

Address: UNIVERSITY OF CAPE COAST, DEPARTMENT OF BUSINESS AND SOCIAL SCIENCES EDUCATION

General Information about Research

My name is Mr Blankson Kwaku Adjei, a PhD student pursuing a programme in Curriculum and Teaching at the Department of Business and Social Sciences Education at the University of Cape Coast. I am conducting a research on the topic "INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE". The study seeks to examine teachers' knowledge regarding the standards-based mathematics curriculum and how such knowledge influences the implementation and students' performance. I feel that engaging you to participate in this study would provide useful insights. If you accept as a participant, you will be engaged for a duration of 40 to 60 minutes on a day you are contacted within one month period.

Procedures

To find answers to the questions in the questionnaire and interview guide, I invite you to take part in this research project. If you accept, you will be required to complete a 20-30 minute closed-ended items from the questionnaire which will be provided by me and as well collected by me. You are being selected because I feel engaging you would provide useful insights to the study. Also, you will be interviewed as well. With your permission, a voice recorder will be used to record your responses from the interview. The items from the interview guide are open-ended and will take 20-30 minutes. If you do not wish to answer any of the questions posed during the interview, you may ignore and I will move on to the next question. The interview will take place at your school and no one else but me will be present. The information recorded is considered confidential, and no one else except me will have access to the information documented during your interview. Your involvement in this study will be within one month period.

Possible Risks and Discomforts

The possible risk associated with the study is interviewing you in the classroom may create a tense situation. However, this will be addressed through a cordial relationship.

Possible Benefits

Your participation in this study will advance knowledge about the new standards-based mathematics curriculum and its implementation. Also, the study will inform major stakeholders and policymakers such as the Ministry of Education (MOE), Ghana Education Service (GES) and other Non-Governmental Organisations (NGOs) on teachers' knowledge about the new standards-based



mathematics curriculum and its implementation. This could provide a basis to shape teachers' educational training and professional development to improve instructional practices.

Confidentiality

I will protect the information you will provide and your name will not appear in any report. I will assign each participant an ID code and pseudo names. Information provided will be kept in a password-protected encrypted electronic file and only the researcher will access it.

Compensation

There will be no reward or any form of compensation for participating in this study. The study is purely educational to learn more about teachers' knowledge of the new standards-based mathematics curriculum and how such knowledge influences the implementation and students' performance.

Voluntary Participation and Right to Leave the Research

You are free to join this study and you can stop participating at any time if you feel uncomfortable. Participation is voluntary and no one will be angry with you if you do not want to participate.

Contacts for Additional Information

You may ask me (Blankson Kwaku Adjei) any questions about this study. You can call me at any time on my cell phone numbers: 0248163404/0506376002 or you can email your concerns to: adjeikwakubblankson@gmail.com; blankson.adjei002@stu.ucc.edu.gh

Contact of Ethical Review Board

This research has been reviewed and approved by the Institutional Review Board of the University of Cape Coast (UCCIRB). If you have any questions about your rights as a research participant you can contact the Administrator at the IRB Office between the hours of 8:00 am and 4:30 p.m. through the phone lines [0558093143](tel:0558093143)/[0508878309](tel:0508878309) or email address: irb@ucc.edu.gh.

PART II: VOLUNTEER'S AGREEMENT

The above document describing the benefits, risks and procedures for the research title "INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE" has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

Volunteer's Name:

Volunteer's Signature/Thumbprint.....

Date:



If volunteer cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

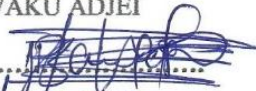
Witness's Name:

Witness's Signature/Thumbprint:

Date:

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

Researcher's Name: BLANKSON KWAKU ADJEI

Researcher's Signature/Thumbprint: 

Date: 16/11/2023

APPENDIX N

Informed Consent Form for Students



CHILD ASSENT FORM

*PART I: INFORMATION SHEET***Introduction**

My name is Mr Blankson Kwaku Adjei, a PhD student pursuing a programme in Curriculum and Teaching at the Department of Business and Social Sciences Education at the University of Cape Coast. I am conducting a research entitled “INFLUENCE OF TEACHERS’ KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS’ PERFORMANCE”. I am asking you to take part in this study because I am trying to learn more about teachers’ knowledge of the standards-based mathematics curriculum and how such knowledge influences the implementation and students’ performance. Hence, your participation would provide useful insights.

Procedure

If you accept to be in this study, you will be required to answer 20 closed-ended items from the students’ mathematics performance test. This will take a duration of 20 to 30 minutes for only one day.

Possible Benefits

Your participation in this study will advance knowledge about the new standards-based mathematics curriculum and its implementation. Also, the study will inform major stakeholders and policymakers such as the Ministry of Education (MOE), Ghana Education Service (GES) and other Non-Governmental Organisations (NGOs) on teachers’ knowledge about the new standards-based mathematics curriculum and how such knowledge influences the implementation and students’ performance. This could provide a basis to shape teachers’ educational training and professional development which could inure to improvement in students’ learning outcomes.

There will be no reward or any form of compensation for participating in this study.

Possible Risks and Discomforts

The possible risk associated with this study is time-consuming answering the 20 test items. However, this risk is minimal.

Voluntary Participation and Right to Leave the Research

You are free to join this study and you can stop participating at any time if you feel uncomfortable. No one will be angry with you or punish you if you do not want to participate or stop participating. Please talk about this study with your parents before you decide whether or not to participate. I will also ask permission from your parents before you are enrolled into the study. Even if your parents/guardian say “yes” you can still decide not to participate.

Confidentiality

I will protect the information you will provide and your name will not appear in any report. I will assign each participant an ID code and pseudo names. Information provided will be kept in a password-protected encrypted electronic file and only the researcher will access it.



Contacts for Additional Information

You may ask me (Blankson Kwaku Adjei) any questions about this study. You can call me at any time on my cell phone numbers: 0248163404/0506376002 or you can email your concerns to: adjeikwakubblankson@gmail.com; blankson.adjei002@stu.ucc.edu.gh or talk to me any time you see me.

Contact of Ethical Review Board

This research has been reviewed and approved by the Institutional Review Board of University of Cape Coast (UCCIRB). If you have any questions about your rights as a research participant you can contact the Administrator at the IRB Office between the hours of 8:00 am and 4:30 p.m. through the phone lines 0558093143/0508878309 or email address: irb@ucc.edu.gh.

PART II: VOLUNTEER'S AGREEMENT

By making a mark or thumb printing below, it means that you understand and know the issues concerning this research study. If you do not want to participate in this study, please do not sign this assent form. You and your parents will be given a copy of this form after you have signed it.

The information which describes the benefits, risks and procedures for the research titled "INFLUENCE OF TEACHERS' KNOWLEDGE ON STANDARDS-BASED MATHEMATICS CURRICULUM IMPLEMENTATION AND STUDENTS' PERFORMANCE" has been read and or explained to me. I have been given an opportunity to ask any questions about the research answered to my satisfaction. I agree to participate.

Child's Name:

Child's Mark/Thumbprint.....

Date:

Witness for volunteer must sign here:

I was present while the benefits, risks and procedures were read and explained to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

Witness's Name:

Witness's Signature/Thumbprint.....

Date:

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above volunteer in the presence of the witness.

Researcher's Name: BLANKSON KWAKU ADJEI

Researcher's Signature/Thumbprint.....

Date: 16/11/2023