

**THE EFFECTS OF HIGH-STAKES ASSESSMENTS ON  
MATHEMATICS INSTRUCTIONAL PRACTICES OF SELECTED  
TEACHERS IN NIGERIAN SENIOR SECONDARY SCHOOLS**

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## **Declaration**

I, the undersigned, hereby declare that the entire work contained in this dissertation is my original work, that I am the sole author thereof, that all the sources that I have used or quoted have been acknowledged by means of complete references, and that I have not previously in its entirety or in part submitted it elsewhere for obtaining any qualification.

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## Abstract

This study investigated the effects of high-stakes assessments on mathematics teachers' instructional, preparatory and assessment practices at senior secondary school level in Kaduna State, Nigeria. High-stakes assessments are standardized examinations administered at the end of every level of education in order to make significant educational decisions about the students, teachers and the schools as well as about graduation, selection and placement of students in different levels of education. The study also investigated how the West African Senior School Examinations (WASSCE) influence teachers' beliefs about what constitutes effective teaching of mathematics. The study also interrogated opportunities and challenges faced by teachers in their continuous assessment (CA) practices for the West African Examinations Council's (WAEC) high-stakes examinations. The essence, therefore, was to find out what mathematics is taught, how it is taught and continuously assessed, the reasons for the practices, and whether they enhanced or diminished prospects for students' success in high-stakes examinations and admission to higher education institutions.

This interpretive study adopted a qualitative ethnographic case study design whose data were generated from lesson observations of ten mathematics teachers, in-depth interviews with the same teachers, and an analysis of related official documents. Data collected through lesson observation protocols and interview schedules were analysed for content and emergent themes. The findings showed that the Kaduna State teachers' mathematics instructional practices were influenced by the WAEC high-stakes examinations in multiple ways. Teachers were observed unsystematically drilling and coaching students, and rushing to cover curriculum content they thought had a high likelihood of being tested in the final examinations. They predominantly employed traditional methods of instruction. Teachers over-emphasized the use of WAEC's past examination question papers sometimes at the expense of the kind of robust conceptual understanding encouraged by Schoenfeld. This reduced most of the instructional, preparatory and continuous assessment practices to the level of what Popham refers to as 'teaching to the test'. Findings from in-depth interviews of teachers were that they believed that their students should pass the WAEC high-stakes examinations at all costs

and to that end believed and preferred instructional strategies that spoon-feed students with solution procedures to be memorised mindlessly for recall during the examinations. Students were not given time to engage in critical thinking or to share multiple problem-solutions strategies.

There were doubts among the teachers about the credibility of the final grades awarded to their students after the inclusion of school-based continuous assessment scores (CA). Reasons were mainly based on mistrust and perceived lack of fairness in arriving at the final scores. Some of the opportunities for teachers in the school system were their involvement in the assessment of students' performance and also that they had opportunities for continuous professional development by WAEC, the government as well as universities.

In short, the mathematics teachers experienced the structuring effects of WAEC's WASSCE and other high-stakes examinations on their instructional and assessment practices. Understanding the influence that shapes the instructional and assessment practices will be valuable in pointing to what it is that needs to be done to reduce the negative effect of high-stakes assessments in order for them to become supportive of instructional practices. Teachers are supposed to be engaged in teaching for understanding and equitable access to legitimate mathematical knowledge for all students and not to be influenced by the excessive demands of high-stakes assessments alone. Teachers need to be supported through appropriate teacher professional development to change their beliefs and to embrace the idea that all students can learn mathematics if treated equitably, recognizing the individual differences that distinguish one student from another, and taking into account these differences in their instructional practices.

**Keywords:** high-stakes assessments, instructional practices, preparatory practices, continuous assessment practices, mathematics, senior secondary school curriculum, West African Senior School Certificate Examinations (WASSCE), washback effect.

## Opsoming

Hierdie studie het die effek van hoëpunte-assesserings op wiskunde-onderwysers se onderrig-, voorbereidings- en assesseringspraktyke op senior sekondêre skoolvlak van onderwys in die Kaduna-staat, Nigerië ondersoek. Hoëpunte-assesserings word beskou as die gestandaardiseerde eksamens wat aan die einde van elke opvoedingsvlak toegedien word, ten einde betekenisvolle opvoedkundige besluite te neem oor die studente, onderwysers en skole en oor die gradeplegtigheid, keuring en plasing van studente in verskillende vlakke van onderwys. Die studie het ook ondersoek ingestel na hoe die Wes-Afrikaanse Seniorskooleksamen (WASSCE) onderwysers se oortuigings oor effektiewe onderrig van wiskunde beïnvloed. Die studie het ook geleenthede en uitdagings vir onderwysers ondervra in hul deurlopende assessering (CA) praktyke vir die Wes-Afrikaanse Eksamenraad se (WAEC) hoëpunte-eksamens. Die wese was dus om uit te vind wat wiskunde geleer word, hoe dit geleer en deurlopend geassesseer word, die redes vir die praktyke en of hulle vooruitsigte vir studentesukses in hoëpunte-eksamens en toelating in hoër onderwysinstellings verbeter of verminder het.

Hierdie interpretatiewe studie het 'n kwalitatiewe etnografiese gevallestudieontwerp aangeneem waarvan die data uit leswaarnemings van tien wiskunde-onderwysers gegenereer is, in-diepte onderhoude van dieselfde onderwysers en 'n analise van verwante amptelike dokumente. Data wat ingesamel is deur leswaarnemingsprotokolle en onderhoudskedules is ontleed vir inhoud en ontluikende temas. Die bevindinge het getoon dat die Kaduna-staatsonderwysers se wiskunde-onderrigpraktyke op verskeie maniere beïnvloed is deur die WAEC-toetse. Onderwysers is waargeneem om ons stelselmatig te boor en af te lei en studente te hardloop om kurrikuluminhoud te dek wat hulle gedink het, het 'n hoë waarskynlikheid gehad om in die finale eksamens getoets te word. Hulle het hoofsaaklik tradisionele onderrigmetodes gebruik. Onderwysers het die gebruik van WAEC se eksamenvraestelle soms beklemtoon ten koste van robuuste konseptuele begrip aangemoedig deur Schoenfeld. Dit het die meeste van die onderrig-, voorbereidings- en (kontinue) assesseringspraktyke verminder tot die soort wat Popham na verwys as 'onderrig aan die toets'. Bevindinge uit in-diepte onderhoude van onderwysers was dat hulle die geloof geglo het dat hul studente die WAEC-hoëpunte-

eksamens ten alle koste moet slaag en daartoe geleer het dat hulle onderrigstrategieë gehad het wat studente met oplossingsprosedures gesmeer het om onophoudelik te onthou vir herroeping tydens die eksamens. Studente het nie tyd gekry om kritiese denke aan te pak of om verskeie probleemoplossingsstrategieë te deel nie.

Daar was uitdagings onder die onderwysers oor die geloofwaardigheid wat toegeken kon word aan die finale grade toegeken aan hul studente na die insluiting van skoolgebaseerde deurlopende assesseringstellings (CA). Redes was hoofsaaklik gegrond op wantroue en waarneembare gebrek aan regverdigheid om die finale punte te bereik. Van die geleenthede vir onderwysers in die skoolstelsel was hul betrokkenheid by die assessering van studenteprestasie en ook dat hulle geleenthede gehad het vir voortgesette professionele ontwikkeling deur WAEC, die regering sowel as universiteite.

Kortom, die wiskunde-onderwysers het die strukturering van die WAEC se WASSCE en ander hoëpunte-eksamens op hul onderrig- en assesseringspraktyke ervaar. Om die invloed van die onderrig- en assesseringspraktyke te begryp, sal waardevol wees om te wys op wat dit is wat gedoen moet word om die negatiewe effek van hoëpunte-assesserings te verminder om onderrigpraktyke te ondersteun. Onderwysers is veronderstel om betrokke te wees by onderrig om te verstaan en regverdigte toegang tot regmatige wiskundige kennis vir alle studente te hê en nie beïnvloed te word deur die oormatige eise van hoëpunte-assesserings alleen nie. Onderwysers moet ondersteun word deur toepaslike onderwyser professionele ontwikkeling om hul oortuigings te verander en om die idee te omhels dat alle studente wiskunde kan leer indien hulle billik behandel word, en erken die individuele verskille wat een student van 'n ander onderskei en rekening hou met hierdie verskille in hul onderrigpraktyke.

**Sleutelwoorde:** hoëpunte assesserings, onderrigpraktyke, voorbereidende praktyke, deurlopende assesseringspraktyke, wiskunde, senior sekondêre skole, Wes-Afrikaanse Seniorskool Sertifikaat-eksamen (WASSCE), spoel-effek.

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## **Dedication**

I dedicated this dissertation to the Almighty God, my late parents, Pa Daniel Bosan, and Ma Sabina Bosan, and my wonderful wife Mrs Roseline Patrick Bosan and the children.

## Acronyms

AACA	Actual Aggregated of Continuous Assessment
CA	Continuous Assessment
CAS	Continuous Assessment Scores
CESAC	Comparative Education Study and Adaptation Centre
CCK	Common content knowledge
EFA	Education For All
FGN	Federal Government of Nigeria
FRN	Federal Republic of Nigeria
JAMB	Joint Admission and Matriculation Board
JCCE	Joint Consultative Committee on Education
MACA	Moderated Aggregate of the Continuous Assessment
Mkft	Mathematical Knowledge for Teaching
NABTEB	National Business and Technical Education Board
NBTE	National Board for Technical Education
NCCE	National Commission for Colleges of Education
NCE	National Council on Education
NEC	National Education Council
NECO	National Examination Council
NERDC	Nigerian Educational Research and Development Council
NGO	Non-Governmental Organization
NMC	National Centre for Mathematics
NPE	National Policy on Education
NTI	National Teacher Institute
NUC	National University Commission
PCK	Pedagogical Content Knowledge
SBA	School-Based Assessment
SDG	Sustainable Development Goal
SMK	Subject Matter Knowledge

SSS	Senior Secondary School
REC	Research Ethical Committee
TCA	Total Continuous Assessment
TRU	Teaching for Robust Understanding
UTME	Unified Tertiary Matriculation Examination
WAEC	West African Examination Council
WASSCE	West African Senior School Examination

## Table of Contents

Declaration .....	ii
Abstract.....	iii
Opsoming.....	v
Acknowledgements .....	vii
Dedication .....	viii
Acronyms .....	ix
Table of Contents.....	xi
List of Figures.....	xvii
List of Tables.....	xx
CHAPTER 1 INTRODUCTION AND ORIENTATION TO THE STUDY.....	1
1.1 Introduction.....	1
1.2 Problem statement .....	1
1.3 Motivation for the study .....	2
1.4 Background of the study.....	5
1.4.1 Nigerian’s National Policy on Education .....	5
1.4.2 High-stakes assessments in Nigeria .....	9
1.4.3 Teachers’ lack of skills to teach mathematics effectively .....	15
1.4.4 History of the West African Examination Council (WAEC).....	16
1.4.5 WAEC assessment practices.....	18
1.4.6 Documents analysis for background information on curriculum and assessment 20	
1.4.7 Kaduna State senior secondary schools, Nigeria as the study area .....	27
1.5 Aims and objectives of the study .....	29
1.6 Research questions.....	29

1.7	Significance of the study.....	30
1.8	Ethical issues .....	31
1.9	Delimitations and key assumptions .....	31
1.10	Referencing method .....	32
1.11	Definition of key terminology .....	33
1.12	Outline of the thesis chapters .....	35
1.13	Conclusion.....	39
CHAPTER 2 LITERATURE REVIEW .....		40
2.1	Introduction.....	40
2.2	Mathematics teachers' instructional practices .....	40
2.3	Examination-driven Instruction (EDI).....	52
2.4	Washback effect of high-stakes assessments.....	54
2.5	Revision practices for high-stakes assessments .....	55
2.6	Influence of high-stakes assessments on the senior secondary school mathematics curriculum.....	62
2.7	Use of instructional materials in senior secondary school mathematics .....	66
2.8	Pillars of mathematics teachers' decision making in their instructional practices	67
2.9	Mathematics teachers' self-efficacy as a construct in instructional practices .....	68
2.10	Mathematics teacher knowledge as a variable in mathematics instructional and assessment practices.....	70
2.10.1	Dimensions of teacher knowledge for effective mathematics instructional and assessment practices .....	71
2.10.2	The state of teachers' mathematical PCK in instructional and assessment practices.....	74
2.10	Mathematics teachers' beliefs on effective mathematics instructional practices .	76
2.11	Teachers' goals for instructional practices and high-stakes assessments.....	82

2.12	Teacher orientations.....	83
2.13	Mathematics teachers preparatory and assessment practices in Nigeria.....	83
2.14	Continuous assessment (CA) practices in Nigerian senior secondary schools and in high-stakes assessments .....	85
2.15	Fair assessment practices in senior secondary schools and WAEC high-stakes examinations .....	94
2.16	Challenges faced by senior secondary school mathematics teachers and WAEC high-stakes examination in implementing continuous assessment .....	94
2.17	Statistical analysis of student achievement in mathematics assessments .....	96
2.18	Effects of high-stakes assessments on instructional and assessment practices	97
2.19	Professional development as an opportunity for mathematics teachers to cope with challenges of classroom instructional and assessment practices for high-stakes assessments .....	98
2.20	The missing link in the literature .....	99
2.21	Conclusion.....	101
CHAPTER 3 THEORETICAL AND CONCEPTUAL FRAMEWORKS .....		102
3.1	Introduction.....	102
3.2	Theoretical frameworks .....	103
3.2.1	Popham' framework for mathematics teachers' instructional and assessment practices.....	105
3.2.2	Schoenfeld's framework of teaching for robust understanding (TRU), sense making in mathematics and balanced assessment.....	108
3.2.3	Bloom's taxonomy of educational objectives in mathematics classroom instruction/assessment and the high-stakes examinations .....	113
3.3	Conceptual framework on the effect of high-stakes assessments on mathematics teachers' instructional practices in Nigerian .....	117

3.4	Conclusion.....	121
CHAPTER 4 RESEARCH METHODOLOGY .....		122
4.1	Introduction.....	122
4.2	Research design .....	122
4.2.1	Qualitative research .....	124
4.2.2	Research paradigm.....	127
4.2.3	Case study design .....	128
4.2.4	Ethnography (micro-ethnography) .....	130
4.3	Population and sampling .....	132
4.4	Research methods and data-collection instruments .....	134
4.4.1	Lesson observations and observation schedule .....	135
4.4.2	Reflection journal as data-collection method .....	138
4.4.3	Interviews.....	141
4.4.4	Archived documents .....	144
4.5	Piloting of research instruments .....	144
4.5.1	Pilot study .....	146
4.6	Data-analysis procedures.....	147
4.7	Trustworthiness .....	151
4.7.1	Credibility .....	152
4.7.2	Transferability .....	154
4.7.3	Dependability .....	155
4.7.4	Confirmability .....	155
4.8	Schedule for data collection .....	156
4.9	Field entry.....	158
4.10	Ethical considerations.....	158

4.11	Scientific integrity .....	160
4.12	Conclusion.....	161
CHAPTER 5 DATA ANALYSIS AND INTERPRETATION OF FINDINGS .....		163
5.1	Introduction.....	163
5.2	Demographics of schools and participants .....	165
5.2.1	Participating senior secondary schools.....	166
5.2.2	Demographics of participants .....	167
5.2.3	Student population and teachers' workload .....	168
5.3	School instructional facilities.....	169
5.4	Initial visits to participating senior secondary schools.....	172
5.5	Lesson observations.....	172
5.6	Effect of high-stakes examinations on mathematics teachers' instructional practices and strategies .....	174
5.6.1	Mathematics teachers' instructional practices and strategies .....	175
5.6.2	Final lesson observations .....	221
5.6.3	Reflections on lesson observations.....	221
5.7	Interviews with teachers on the effect of high-stakes examinations on their instructional practices and strategies .....	223
5.8	Interview results on the effect of WAEC high-stakes examinations on mathematics teachers' beliefs about what it means to teach mathematics effectively .....	236
5.9	Challenges and opportunities faced by senior secondary school mathematics teachers in their continuous assessment practices related to WAEC high-stakes examinations .....	239
5.10	Conclusion.....	244
CHAPTER 6 DISCUSSION, CONCLUSION AND RECOMMENDATIONS .....		247
6.1	Introduction .....	247

6.2 Summary of chapters .....	247
6.3 Summary of findings.....	249
6.4 Discussion.....	250
6.5 Conclusion .....	263
6.6 Contribution to theory and practice.....	266
6.7 Implication for policy and practice .....	267
6.8 Limitations of the study.....	268
6.9 Recommendations .....	269
6.10 Recommendations for further study .....	271
References.....	274
APPENDIX A: Ethics Approval.....	315
APPENDIX B: Approval from Ministry of Education .....	317
APPENDIX C: CONSENT FORM .....	318
APPENDIX D: OBSERVATION SCHEDULE .....	322
APPENDIX E: TEACHER'S INTERVIEW SCHEDULE .....	327
APPENDIX F: TEACHER'S INTERVIEW TRANSCRIPTS.....	331
APPENDIX G: LESSON OBSERVATION TRANSCRIPTS AND CODING .....	340

## List of Figures

Figure 1.1: The Nigerian 9-3-4 system of education (adapted from Omobude, 2014, p. 10).....	6
Figure 1. 2 Structure of Nigerian system of education from primary to tertiary education	8
Figure 1. 3: Summary of the research structure .....	37
Figure 2. 1 The decision-making process (Schoenfeld, 2011, p. 3). .....	67
Figure 2. 2: Model of teacher knowledge (Adapted from Grossman, 1990, p. 5) .....	72
Figure 2.3: Model of teachers' mathematical knowledge for teaching (Adapted from Ball <i>et al.</i> , 2008, p. 403) .....	73
Figure 3.1: Theoretical frameworks for the study .....	104
Figure 3. 2: Popham's five attributes of an instructionally useful assessment (adapted from Popham, 2003b, p. 49).....	107
Figure 3. 3: Popham's five attributes of an instructionally useful assessment (adapted from Popham, 2003b, p. 49).....	112
Figure 3. 4: The four dimensions of Krathwohl's categories of knowledge.....	116
Figure 3.5: Conceptual framework of effect of high-stakes assessments on mathematics teachers' instructional and assessment practices.....	119
Figure 4. 1 Research design and methodology for this study.....	123
Figure 4. 2 Sources and generation of research data.....	134
Figure 4. 3 Determining the trustworthiness of research instruments.....	145
Figure 5.1 Picture of teacher-students interaction during instructional practices.....	171
Figure 5.2: Students' classwork question on modular arithmetic (WAEC 2015, question 11(c)).....	176

Figure 5.3: Assignment question given to the students on direct and inverse variations	178
Figure 5. 4: Questions on variation (WAEC 2015, question 5b)	179
Figure 5. 5: Classwork on multiplication of matrices and how to find transpose of matrices	181
Figure 5.6: How to solve multiplication, division of logarithms and solving exponentials and roots of logarithms	182
Figure 5. 7: Assignment on multiplication and division of logarithms, solving exponentials and roots of logarithms	184
Figure 5. 8: Classwork and the assignment on simplification of surds given to the students	185
Figure 5. 9: Example on solving simultaneous equations using elimination method	187
Figure 5.10: The two quadratic equations solved the by teacher during his lesson	188
Figure 5. 11: Revision questions on the quadratic equations, inequality and simultaneous equations (WAEC, 2014 question 10a and WAEC 2016a & b)	189
Figure 5.12: Examples solved by the teacher with the students on simple and compound interest	191
Figure 5.13: Example questions on depreciation solved as examples to the students	192
Figure 5.14: Example of trigonometrical function solved with the students	193
Figure 5. 15 Graph of trigonometrical function solved with the students	193
Figure 5. 16: Example of the frequency table and the calculation of mean (WAEC, 2016, question 9 a)	196
Figure 5. 17: Practice question on finding the mean	199
Figure 5. 18: Assignment question on quadratic equation Graph (WAEC 2015, question 7a, b, c)	201
Figure 5. 19: Graph on quadratic equation $y = px^2 - 5x + q$	201
Figure 5.20: Assignment on profit and loss (WAEC 2014, question 6b)	203
Figure 5. 21: Two of the example questions on simple and compound interest	204
Figure 5. 22 Quadratic equations solved by the students	205
Figure 5. 23: The assignment given to the students on statistics	208
Figure 5. 24: The bar chart representing students' marks in statistics examination	208

Figure 5. 25: Classwork questions on simple and compound interest (WAEC 2016, question 1b) .....	210
Figure 5. 26: An assignment question on calculating annuity.....	211
Figure 5. 27: The question solved by a student on the board.....	213
Figure 5. 28: Assignment questions on simple and compound interest .....	216
Figure 5. 29: Assignment on how to solve problems in indices using different methods .....	217

## List of Tables

Table 1. 1 Nigerian mathematics education agencies, high-stakes examination bodies and their responsibilities (Adapted from Omobude, 2014, p. 10) .....	11
Table 1. 2 WAEC grading system in the WASSCE .....	18
Table 1. 3 The national mathematics curriculum (adapted from NERDC, 2007).....	21
Table 1.4 WAEC mathematics syllabus.....	23
Table 1. 5 May/June WASSCE question papers in mathematics from 2013 to 2017 .....	27
Table 2.1: Instructional elements, recommended instructional and assessment practices in mathematics (Adapted from The Education Alliance, 2006).....	46
Table 2. 2: Teachers' beliefs about effective teaching of mathematics (Raymond, 1997, p. 560).....	78
Table 3.1: The five dimensions of a powerful mathematics classroom (Schoenfeld, 2017a, p. 1).....	109
Table 3. 2 Smith's Taxonomy (Smith <i>et al.</i> , 1996).....	114
Table 4.1: Coding and categorization of lesson observations (see Appendix D).....	148
Table 4.2: Themes used for data analysis.....	149
Table 4.3: Measures for enhancing trustworthiness in qualitative research .....	152
Table 4. 4 Timeline for data collection.....	156
Table 5. 1 Demographics of schools .....	166
Table 5. 2 Demographics of participants .....	167
Table 5. 3: Student population and teachers' workload.....	168
Table 5. 4 Schools' instructional facilities .....	170
Table 5. 5 Summary of lesson observations .....	218



## **CHAPTER 1**

### **INTRODUCTION AND ORIENTATION TO THE STUDY**

#### **1.1 Introduction**

In this study high-stakes assessments refer those standardized tests or examinations administered at the end of every level of education (from primary to senior secondary school, equivalent to Grades 1 to 12) for making decisions about the pupils/students, teachers and the schools (Aysel, 2012; Heubert, 2000; Smyth, Banks & Calvert, 2011). This is because high-stakes assessments do not refer only to matriculation examinations (as in Grade 12, the high school exit examinations in South Africa). They may be primary school exit examinations (Grade 6 or 7) critical for placement in premier high schools. They could even be pre-school assessments for placement in premier or highly selective primary schools. At any of these stages teachers preparing learners for the high stakes' assessments need to know what is expected and adjust their teaching accordingly.

These examinations are termed 'high stakes' because they help in making decisions about students' graduation, and then selecting and placing them into different education institutions (Reynolds, Livingston & Willson, 2009). In other words, passing these examinations has significant consequences for the pupils/students. This study investigates the effects of high-stakes West African Senior School Certificate Examinations (WASSCE) on the mathematics classroom instructional practices (teaching styles and strategies that assist students learn worthwhile mathematical content in school) at senior secondary schools in Nigeria. It delved into how high-stakes West African Senior School Certificate Examinations (WASSCE) in senior secondary school mathematics affect classroom instruction and continuous assessment practices, and how classroom instruction, in turn, affects outcomes in the high-stakes assessments. The focus is on identifying the methodologies, curriculum, choice of textbooks, homework, assessment methods used in the senior secondary schools and why.

#### **1.2 Problem statement**

Assessment of students in high-stakes examinations is very critical because it is affected by teachers' beliefs and their ability to match their instructional practices to students'

learning styles to produce accurate assessments (McMillan, 2008). However, in order to align mathematics teaching and assessment practices, the readiness of the students, teachers' mathematical proficiency and effective use of appropriate instructional practices are important factors (Chales-Ogan & Otikor, 2016). The traditional methods that emphasize the solving of mathematics problems that must produce accurate answers, cover the syllabus and the massed coaching of students to pass examination are sometimes dull and frustrating (Mitchell, 2006). Yet this is the dominant approach in many resource-constrained Nigerian senior secondary schools, and Kaduna State is no exception. However, the alternative methods could also be dull and frustrating. No method is the ultimate solution, but the teachers' effectiveness in their instructional practices and strategies that engage the students for conceptual understanding, equitable access to legitimate mathematical knowledge should be the focus of concern for mathematics education.

Another problem is which aspects of mathematics should be taught, and which ones hold better prospects for students' success in high-stakes examinations and in higher education institutions, especially those institutions that offer science, technology, engineering and mathematics (STEM) education programmes in Nigeria. Mathematics teachers also experience the structuring effects of the West African Examination Council's West African Senior School Examinations (WAEC's WASSCE) and other high-stakes examinations on their instructional and assessment practices. Understanding these influences will help in reducing the counter-productive effects of high-stakes assessments and make them supportive of instructional practices.

### **1.3 Motivation for the study**

The first motivation for this study is the emphasis placed on students' performance in high-stakes examinations and the possibility of teaching and learning mathematics 'to the test' rather than teaching for knowledge, problem solving, critical thinking and innovative thinking skills. There have been a few studies on the effects of high-stakes assessments on mathematics instruction and instructional practices in high-stakes assessments in Nigeria (Anikweze, 2005; Idowu & Esere, 2009; Modupe & Sunday, 2015; Oguneye,

2002). However, those studies are not based on strong evidence (Mitchell, 2006). The question is whether 'teaching to the test' is good or not.

Baker (2004) thinks that teaching to the test can be good if the set standards, curriculum and assessments are all aligned. Teaching to the test can be good when teaching to the test incorporates instructional strategies that engage students in acquiring knowledge, problem solving, critical thinking and innovative thinking skills to make sense of mathematics (Schoenfeld, 2017a). For example, if teachers' instructional practices provide practical and meaningful mathematics activities and incorporate items on the high-stakes assessments, such teachers direct their instructional strategies toward achieving knowledge and skills. Popham (2001b) refers to instructional practices that are directed toward the curriculum content represented by high-stakes assessments items as curriculum teaching. Teaching to the test that spoon-feeds the students to memorise solution procedures for recall during the test without any conceptual understanding is considered inappropriate. Teaching to the test can be bad when the knowledge acquired from instruction becomes elusive and vanishes after the test has been administered.

Combining effective teaching and meaningful learning of mathematics with preparation for high-stakes assessment will yield a better result rather than focusing on drilling students on solution procedures for examinations alone (Langer, 2001; Yeh, 2005). In the Nigerian context, teachers might teach to the test because education is seen as assessment-driven. These instructional practices do not give students opportunities to engage in critical thinking and share multiple solution strategies. The senior secondary school mathematics teachers are therefore, always required to complete the teaching of the content of the curriculum in time and coach students with reference to past examinations. How smartly they do this, is open to question. Is it the means that must justify the end, or is it the end that justifies the means? The effects of high-stakes examinations on mathematics instructional practices need to be probed to produce more empirical evidence, because the evidence as to whether high-stakes assessments lead to a high standard of education or not is contradictory (Yeh, 2005).

The second motivation for this study is the importance attached to mathematics in the development of science and technology worldwide. Baiyelo (2007) observes that

Mathematics is the language of science and technology. This means mathematics knowledge and skills are applied in science and technology. For example, concepts such as vectors, calculus, logarithms and arithmetic are applied to solve scientific and technological problems. Abiodun (1997) similarly states that mathematics is a gateway subject and key to the study and development of the sciences, while science is the bedrock of technological advancement. Salmon (2005) supports the view that mathematics is a precursor of scientific discoveries and inventions. Mathematics knowledge determines the level of scientific and technological development of any nation (Azuka, 2003; Bajah, 2000; Daso, 2012; Iji, 2008; Imoko & Agwagha, 2006; Musa & Dauda, 2014; Ukeje, 1977). The developed countries are so called because they have gone far in science and technological development.

Therefore mathematics is the linchpin in the task of national capacity building in science and technology, and any shortcomings in this subject constitute drawbacks to the achievement of our science and technology objectives as well as the aims of Education For All (EFA), the Sustainable Development Goals (SDGs) and the transformation agenda (Adetula, 2010, 2015; Ugoh, 1980). One can profess that mathematics is the best cognitive tool that moves these science and technology activities in today's era of globalization. However, many students are unable to gain admission to study science and technology-related courses in the higher education institutions in Nigeria because they lack credit passes in mathematics in the matriculation West African Senior School Certificate Examination (WASSCE) or its equivalent. Despite the importance placed on mathematics, numerous researchers (e.g. Agwagah, 2001; Amazigo, 2000; Daso, 2012; Maduabum & Odili, 2006; NERDC, 1992; Odili, 1986; Okereke, 2006; Okigbo & Osuafor, 2008; Salau, 1995) have observed that senior secondary school students do not have an interest in mathematics and their performance in the high-stakes assessments is always poor. Ukeje (1986) observed that mathematics is one of the most poorly taught, widely hated and abysmally understood subjects in senior secondary school, and students, particularly girls, flee from taking the subject. In this regard, Musa and Dauda (2014) note that most students, teachers, parents/guardians and stakeholders in education are dismayed by the effect of these high-stakes examinations on entry requirements into tertiary institutions in Nigeria.

Additionally, teachers are the major factors in the success of the mathematics curriculum, because they use the curriculum as reference document in their instructional practices for effective teaching and meaningful learning of mathematics (Graham & Fennell, 2001; Walsaw, 2010), and they also make the most important contribution to the students' achievements in mathematics (Ball & Forzani, 2009; Ball, Sleep, Boerst, & Bass, 2009). Despite the public and private teaching/learning resources made available to Nigerian senior secondary schools, the researcher's observations and experience as a mathematics teacher and teacher educator is that the students' performance both in the classroom and at WAEC high-stakes assessments is poor. Therefore, addressing the teachers' role in their instructional practices is seen as a remedy for the students' poor performance (Even & Tirosh, 2008; Hiebert & Carpenter, 1992; Schoenfeld, 2011), with the teachers' knowledge, beliefs and self-efficacy being some of the most important variables that influenced classroom instructional practices (Fennema & Franke, 1992; Ghaith, 2003; Pajares, 2002; Turner-Bisset, 2001). Hence, the need to investigate the differential effects of these time-restricted high-stakes examinations (such as WASSCE) on mathematics instructional and assessment practices.

## **1.4 Background of the study**

### **1.4.1 Nigerian's National Policy on Education**

After independence in 1960 Nigeria formulated its indigenous National Policy on Education (NPE), in 1969 known as 6-3-3-4: 6 years primary (elementary), 3 years junior secondary, 3 years senior secondary and 4 years tertiary education, which was implemented in 1982. It was later modified slightly in 1999 to 9-3-4: 9 years basic education (6 years primary and 3 years junior secondary combined), 3 years senior secondary and 4 years tertiary education (Ayodele, 2013; FRN, 2014). There are, concomitantly, two categories of schools – public and private. There are also high-stakes assessments at the exit point of primary, junior and senior secondary levels of the education system. On the one hand, the term 'public schools' refers to institutions owned, managed and funded by either a state or the federal government of Nigeria. On the other hand, the term 'private schools' refers to institutions owned, managed and funded by private individuals, corporates and/or non-governmental organizations (NGOs). The

teachers in these schools are expected to teach mathematics effectively and assess their students using classroom and high-stakes assessment for the graduating classes for selection and placement in the next level of education. Figure 1.1 below gives the Nigerian 9-3-4 system of education.

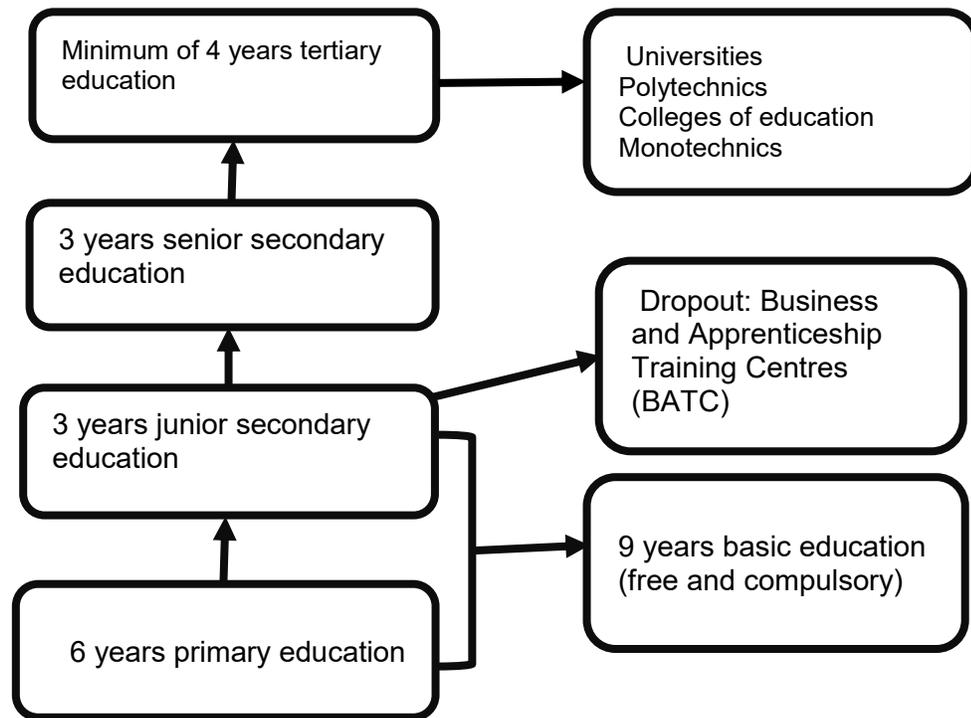


Figure 1.1: The Nigerian 9-3-4 system of education (adapted from (Omobude, 2014, p. 10).

According to the National Policy of Education (FRN, 2004), students who complete junior secondary school would be selected and placed in senior secondary schools (SSS), technical colleges, out-of-school (dropouts) vocational training centres and apprentice schemes. In principle, those students who fail the junior school certificate (JSC) training are considered as dropouts and are to go to out-of-school vocational training centres and apprentice schemes to learn different vocational professions and entrepreneurship such as carpentry, electrician, plumbing, mechanics, amongst others. These Business Apprentice Training Centres (BATC) were built in all 36 states of the Federal Republic of Nigeria. Teachers' effectiveness in their instructional practices and students' meaningful learning are determined by students' performance in high-stakes assessments at all levels of education.

The Federal Ministry of Education through the National Council on Education (NCE) released a new basic education mathematics curriculum to be implemented by schools and high-stakes examination bodies in 1999. The new mathematics curriculum consists of objectives, subject matter, teaching methods and evaluation procedures (Oyetunde, 2002). The emphasis in the new curriculum is to help students see the relevance of mathematics to real life rather than merely treating it as a collection of abstract concepts. The new curriculum also advocates for training and retraining of mathematics teachers in order to upgrade their mathematical knowledge and didactic skills to facilitate meaningful learning and student success in high-stakes examinations (Ekwueme & Meremikwu, 2010; FRN, 2014). This professional development was aimed at improving teachers' instructional and assessment practices for student success in high-stakes assessments. Figure 1.2 illustrates the structure of Nigerian education from pre-primary to tertiary. The tertiary level of education is included because the WAEC high-stakes examinations prepare the senior secondary school students for graduation, selection and placement in Nigerian tertiary institutions.

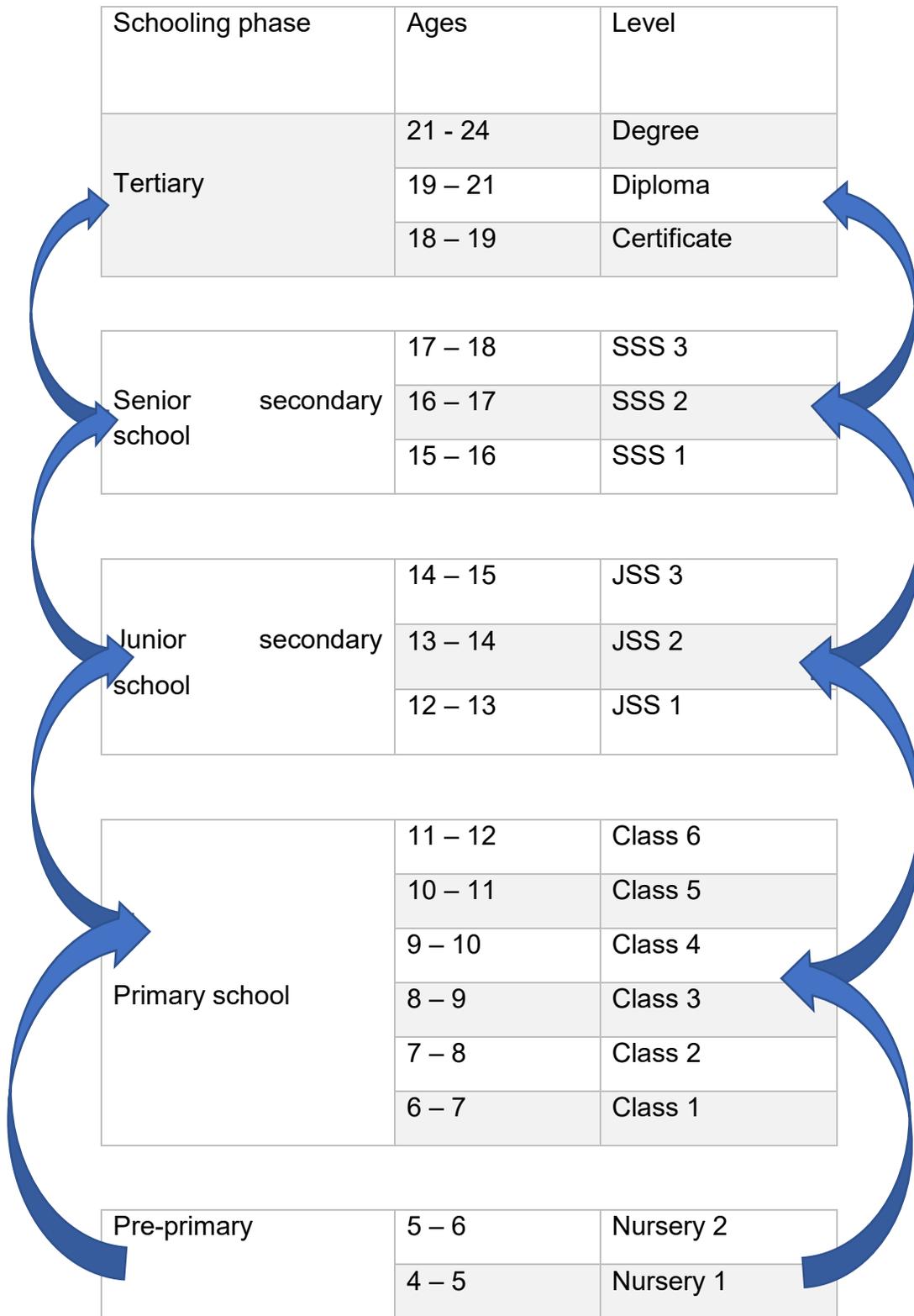


Figure 1.2: Structure of Nigerian system of education from primary to tertiary education

From Figure 1.2, at the age of 6 Nigeria children begin primary education and spend the next six years on this before graduation at the age of 12. After completing of the first six years of learning, the pupils are promoted to the junior secondary school level through the First School Leaving Certificate Examination (FSLCE) and obtain the First School Leaving Certificate (FSLC). The junior secondary school lasts for three years with minimum ages between 12 and 15. Students write the Junior School Certificate Examination (JSCE) after three years and those who are qualified are awarded the Junior School Certificate (JSC) (FRN, 2014). The criteria for obtaining the FSLC and JSC are through intensive instructional practices and the use of high-stakes assessments.

#### **1.4.2 High-stakes assessments in Nigeria**

Standardized high-stakes assessments are set for some norm-referenced or criterion-referenced grades or symbols to determine students' performance. The aim of assessing senior secondary school students in mathematics is to provide a norm-referenced interpretation (McMillan, 2008; Modupe & Sunday, 2015; Popham, 2008). The focus of high-stakes examinations is to be objective and neutral to all students taking the examination. These assessments are also used to ensure accountability of educational systems that are focused on students' achievement (Glaser & Silver, 1994). High-stakes assessments are any standardized examination that is used for making decisions about students, educators and schools, and to determine punishments, accolades, academic advancement and compensation (Abbott, 2014). Additionally, the stakes are high because there are consequences for students, such as career choices and economic opportunities.

There are high stakes assessments in all countries of the world (Nigeria inclusive). These examinations are called "high-stakes" because students who perform poorly will not get admission into higher education institutions. They are also called high-stakes because the results from these assessments are used for decisions making on graduation, for selecting and placing of students into higher education institutions (Anikweze, 2005; Modupe & Sunday, 2015; Reynolds, Livingstone, Wilson, 2009). The results of the

assessments are needed for both policy and practice in education. Therefore, there should be proper monitoring of the entire system for the benefit of the students (Goertz & Duffy, 2003). Teachers should be supported in their instructional, preparatory and assessment practices. Policies should be formulated to support teachers as they prepare students for these assessments. The education system should be organized in such a way that students are motivated with a well-planned curriculum that will cater for the needs of the teachers and the students. This can be done by developing a better curriculum as well as instructional and assessment practices in the senior secondary schools.

High-stakes school assessments or examinations in Nigeria include: the Junior Secondary Certificate Examination (JSCE) administered by the various state ministries of education; the West African Senior School Examination (WASSCE) conducted by the West African Examination Council (WAEC); Senior School Certificate Examination (SSCE) conducted by the National Examination Council (NECO); National Business and Technical Certificate Examination (NBTCE) conducted by the National Business and Technical Education Board (NABTEB); Grade II certificate examination or Teacher Certificate 2 (T C 2) for teacher training colleges in Nigeria conducted by the National Teachers Institute (NTI) and Interim Joint Matriculation Board Examination (IJMBE) conducted by the Institute of Education, Ahmadu Bello University, Zaria. These are syllabus-based examinations and their syllabuses are offshoots of the national curriculum in which mathematics is a core subject (WAEC, 2011). This shows that the WAEC syllabus is based on the national Mathematics curriculum.

There are several agencies and examination bodies that have various responsibilities at different levels of government. Table 1.1 shows the various agencies/bodies and their responsibilities.

Table 1. 1 Nigerian mathematics education agencies, high-stakes examination bodies and their responsibilities (Adapted from Omobude, 2014, p. 10)

<b>Administrative Bodies/Agencies</b>	<b>Responsibilities</b>
Federal Ministry of Education	Centrally coordinate all educational policies/activities like the curriculum development and quality assurance
State Ministry of Education	Coordinate the various states' educational activities
Local Government Primary Education Board	Responsible for all nursery/primary educational administration within the local government
National Educational Research and Development Council (NERDC)	Promote and coordinate all educational research activities in Nigerian
Joint Consultative Committee on Education (JCCE)	An independent body of scholars in education that serves as a purely advisory body to both the federal and state governments
National Universities Commission (NUC)	This commission is responsible for the registration of all universities, accreditation of all the programmes in these universities, and ensuring quality education in all the universities in Nigeria
West Africa Examination Council (WAEC)	This council is responsible for conducting the West African Senior School Certificate Examinations (WASSCE)
National Examination Council (NECO)	The council also conducts an alternative examination at the senior secondary school level – the Senior School Certificate Examinations (SSCE). This is to give the students the opportunity to make choices and remove the monopoly from one examination council – WAEC.
Joint Admissions and Matriculations Board (JAMB)	This board conducts advanced-level universities' matriculation examinations, the Unified Tertiary Matriculation Examinations (UTME)

National Business and Technical Examination Board (NABTEB)	Responsible for organizing all examinations leading to the award of the National Business and Technical Certificate
National Commission for Colleges of Education (NCCE)	This commission supervises all the activities of the colleges of education, which are the main teachers' educational institutions in Nigeria
National Board for Technical Education (NBTE)	Supervision of all the activities of the polytechnics.
National Mathematical Centre (NMC)	Conduct research and coordinate mathematics teachers' professional development activities
Teachers Registration Council of Nigeria (TRCN)	In charge of registration of professional teachers and continued professional development
National Teachers Institute (NTI)	Conduct teacher Grade II Certificate examinations and coordinate primary school teachers' professional development

Table 1.1 explains that the federal ministry of education centrally controls and coordinates the educational policies and activities in Nigeria, while the states ministry of education receives directives from the federal ministry of education and coordinates the educational policies/activities within the states. WAEC, NECO, IJMB, NABTEB and NTI are high-stakes examination bodies. NUC, NCCE and NBTE are regulatory bodies for tertiary institutions in Nigeria. The NERDC promotes and coordinates all educational research activities and reviews of the national curriculum in Nigerian and JCCE serves as advisory board to the federal ministry of education and NERDC. The TRCN oversees teachers' professional development. NMC is concerned with professional development of mathematics teachers at all levels of education in Nigeria and serves as a research institute for mathematics. The local government primary education board is responsible for all educational administration within the local government areas. These are bodies and agencies that are responsible for control, coordination and regulation of educational activities such as reviewing and moderating curriculum, supervising and inspecting the schools and teachers' instructional and assessment practices in the classroom and at the

high-stakes assessments. According to Ukpong and Uko (2017), the reason for Nigeria using public examination bodies for conducting high-stakes examinations is to ensure uniform standards and quality of certificates issued for passing such examinations, in the hope that their conduct does not influence teachers' instructional, preparatory and assessment practices.

The JSCE is used for promotion of junior secondary school students to the senior secondary school. The SSCE conducted by NECO was introduced by the federal government of Nigeria in 1983 to break the monopoly of WASSCE in Nigeria and Anglophone (English-speaking) West African countries. The NABTEB was introduced as a high-stakes examination for commercial and technical colleges and to feed the state and federal polytechnics with students as well as for the development of science and technology in the country (FRN, 2013). The NTI was introduced to replace the former teacher training colleges that were abolished, while the IJMBE is to replace the former Schools of Basic Studies (SBS) that was abolished and to produce students intending to study professional courses in Nigerian universities (for example, students who wish to study medicine, pharmacy, engineering, textiles technology, law, etc.).

Candidates who sit for any of these examinations and wish to proceed to higher education institutions must also sit for the Unified Tertiary Matriculation Examination (UTME), a university entrance examination, administered by the Joint Admission and Matriculation Board (JAMB) to be eligible for admission into any higher education institutions (universities, polytechnics, colleges of education, colleges of health technology, colleges of nursing and midwifery) in Nigeria (FRN, 2013; JAMB, 2009). The condition is that one must have at least five credits, including mathematics and English language, and must additionally sit for the UTME. Candidates are expected to sit for four subjects – English language and any other three relevant to the intended programme of study at university. This is similar to Turkey's and Spain's university admission policies, where secondary school students' academic achievement scores in high-stakes school-leaving examinations and in university entrance examinations are considered jointly for admission purposes (Helms, 2008)

Other existing tertiary institutions using the UTME in Nigeria are the colleges of education, polytechnics and monotechnics (FRN, 2014). Monotechnics are single-subject technological institutions for specialized programmes such as colleges of agriculture, fisheries, forestry, surveying, accountancy, nursing, mining, petroleum, etc. The structure and status of their programmes are equivalent to those of polytechnics. For one to get admitted into any of these higher education institutions one needs to obtain the five credits, including mathematics and English language. Therefore, this study focuses on how mathematics teachers' instructional and assessment practices are influenced by WASSCE as a high-stakes examination for Anglophone West African countries (Nigeria, Ghana, Sierra Leone, Liberia and The Gambia). WASSCE's standard is equivalent to the Cambridge/London Ordinary Level GCE examination (WAEC, 2011). This is one of the reasons that prompt the choice of WAEC's WASSCE as reference among the Nigerian high-stakes examinations bodies for this study.

The senior secondary school mathematics curriculum and WAEC syllabus in Nigeria are reviewed every five years in order to make them relevant to the changes in technology and culture in the society; to address the current socio-economic status of the states; and to keep up with some international standards on the study of the subject (FRN, 2014; NERDC, 2007). It is also intended to implement recommendations of school's inspectors and chief examiners' reports for improvement in the high-stakes examinations, since they are time-restricted assessments.

The curriculum also emphasizes the use of the six levels of Bloom's (1956) revised taxonomy of educational objectives (knowledge, comprehension, application, analysis, synthesis and evaluation) in the assessment practices of mathematics. Hence, Mathematics in WASSCE consists of two papers (multiple-choice items in Paper I and free-response items are in Paper II; Paper II has two sections) to adequately measure these cognitive levels (Bloom, Engelhart, Frust, Hill, & Krathwohl, 1956; Krathwohl, 2002; WAEC, 2011). From the Chief Examiners' reports and the researcher's experience as an examiner in the WASSCE, students avoid questions on certain topics in the examination and there is a recurring pattern of poor performance in such topics. Some of the problematic topics include coordinate and circle geometry, trigonometry, bearings and

distances, longitudes and latitudes, logical reasoning, calculus, construction and loci, modular arithmetic and mapping (FRN, 2014).

### **1.4.3 Teachers' lack of skills to teach mathematics effectively**

Teachers in Nigerian senior secondary schools lack the skills to teach mathematics effectively as reflected in the poor performance of students in WAEC's WASSCE (Ogundele, Olanipekun, & Aina, 2014; Musa & Dauda, 2014). Ogundele, Olanipekun and Aina (2014) review the causes of this poor performance in WASSCE in Nigeria. Students' performance has become so weak that stakeholders in education are trying to figure out the reasons for such poor performance. It was revealed that the mass failure rate may be attributed to several factors. The factors included students, teachers, the school, government, language of instruction, among others. It was recommended that stakeholders in education section should play their role responsively in order to deal with this failure.

Despite efforts made by government to improve the performance of students in mathematics, there are still problems in the teaching/learning process of mathematics in Nigeria. Odilli (2006, p. 18) listed some of these problems: lack of curriculum integration, shortage of mathematics teachers, lack of instructional materials, poor government policy, poor classroom organization by teachers, lack of properly equipped mathematics laboratories for practical work, excessive student numbers, teachers' impatience and lack of preparedness, and poor remuneration of teachers.

It was also observed that only a few courageous students attempted questions on the topics perceived to be difficult in the WAEC high-stakes mathematics examinations. It may be either the students were not taught the topics by their teachers (skipping the topics) or were taught only the introductory aspects of the topics. It could also be a lack of subject matter knowledge (SMK), pedagogical content knowledge (PCK), or curriculum knowledge (CK) (Shulman, 1986a, 1987), Mathematical Knowledge for Teaching (MKfT) or constraints in teaching/learning resources (Adler, 2012; Ball, Thames, & Phelps, 2008; Helms, 2008). It could also be the negative effects of massed and distributed practices, spiral revision or time-restricted assessment practices. Some secondary schools in

Nigeria have class sizes of between 50 to 100 students. It is the goal of this study to unravel the coping strategies adopted by mathematics teachers in their instructional practices.

The major and reoccurring question is: What can we do to develop the teaching and learning of mathematics in Nigerian secondary schools, especially when all major stakeholders consider mathematics as a tool for self-reliance?

#### **1.4.4 History of the West African Examination Council (WAEC)**

The University of Cambridge Local Examinations Syndicate (UCLES), University of London School Examinations Matriculation Council (ULSEMC) and West African Departments of Education (WADE) met in 1948 concerning education in West Africa. The meeting was held to discuss the future policy of education in West Africa. During the meeting Dr George Barker Jeffery was appointed to visit some West African countries to conduct a feasibility study to assess the general education level and requirements in West Africa. After Jeffery's three-month visit to Nigeria, Ghana, Sierra Leone, Liberia and the Gambia, he came up with a report on the need for a West African Examination Council and provided detailed recommendations on the composition and duties of the Council. Following this report, the groups met with the governments of these countries and agreed on establishing a West African Examination council by fully adopting Jeffery's recommendations (WAEC, 2014). The ordinance establishing the Council emphasized that the certificates conferred by WAEC must be of the same standard as other that of examination bodies in Britain.

For the establishment of the council, the legislative assemblies of Ghana, Nigeria, Sierra Leone, Liberia and the Gambia passed an ordinance (West African Examinations Council Ordinance No. 40) approving the establishment of an inter-territorial West African Examination Council in December 1951. The main functions of the council are to review and consider annually the examinations to be held in West Africa, and to conduct the examinations as well as award certificates and diplomas based on the results of the examinations conducted. Despite the inter-territorial structure of the council, the ordinance agreed to the coordination of examinations and issuing of certificates to

students in individual countries by the West African Examination Council (i.e. each member country administered the WASSCE within its own jurisdiction or territory).

The council is responsible for the conduct of the national examinations, international examinations, and examinations administered on behalf of other examining bodies. The council's international examination is the West African Senior School Certificate Examination (WASSCE). It is the council's international examination that replaced the General Certificate of Education (Ordinary/Advance level) examinations. The WASSCE has become part of the educational reform programmes in member countries. The examination is administered twice a year, in May/June and in November/December. One unique feature of the WASSCE is the use of school-based continuous assessment (CA) scores with the WASSCE according to a certain ratio (WAEC, 2017). This study will verify how WAEC high-stakes examinations combine school-based continuous assessment (CA) scores with the WASSCE scores in mathematics and the fairness of these assessment practices in Nigerian senior secondary schools and WAEC, and whether the scores emanating from school-based CA and WASSCE are authentic and an actual or true reflection of students' performance.

The council has made a laudable contribution to education in the Anglophone countries of West Africa with the number of examinations they have coordinated; the certificates they have issued have enabled candidates to qualify for admission into universities and other tertiary institutions (other higher education institutions). They also set up an endowment fund to contribute to education in West Africa as well as organizing lectures, and supporting those who cannot afford education. According to Adeyegbe (2004), the council is constituted of a team of experts for the conduct of all examinations in the member countries.

However, WAEC was not the main reason for this study, it was used as reference point to investigate how high-stakes assessments influence Kaduna State senior secondary school mathematics teachers' instructional, preparatory and assessment practices. WAEC is not the only high-stakes examination body in Nigeria (see section 1.4.2). The researcher chose the WAEC high-stakes examination body because it is an examination body that administers examinations in West African Anglophone countries (Nigeria,

Ghana, Sierra Leone, Liberia and the Gambia) which has more credibility than an indigenous examination body.

One indisputable or irrefutable fact is that the students' WASSCE poor performances throughout the federation over the years in mathematics are a reflection, at least in part, of the poor state of instructional practices in the Nigerian schools and a serious indictment of senior secondary education in Nigeria (Adetula, 2015). Table 1.2 gives a breakdown of WAEC grading system in the WASSCE.

Table 1. 2 WAEC grading system in the WASSCE

Percentage scores	Letter grade	Description	Grade point
75 – 100	A <sub>1</sub>	Excellent (Distinction)	4.0
70 – 74	B <sub>2</sub>	Very Good	3.5
65 – 59	B <sub>3</sub>	Good	3.0
60 – 64	C <sub>4</sub>	Credit	2.5
55 – 59	C <sub>5</sub>	Credit	2.0
50 – 54	C <sub>6</sub>	Credit	1.3
45 – 49	D <sub>7</sub>	Pass	1.0
40 – 44	(E <sub>8</sub> )	Pass	0.5
0 – 39	F <sub>9</sub>	Fail	0

From Table 1.2 it can be seen that students intending to proceed to university must, as a rule, score a minimum of credit grade C<sub>6</sub> in at least five relevant subjects, including mathematics and English language, in order to be considered for admission into any university. Students who are able to meet these minimum requirements are further required to sit and pass another examination called the Unified Tertiary Matriculation Examination (UTME), which is organized by another examination body called the Joint Admission and Matriculation Board (JAMB).

#### 1.4.5 WAEC assessment practices

At the end of senior secondary school three (SSS3), students sit for WASSCE and other national examinations such as SSCE, NABTEB, among others (see section 1.4.2). They

are assessed in eight or nine subjects depending on their choices. Schools participating in WASSCE send continuous assessment (CA) scores of at most 20% to WAEC high-stakes examinations to form part of candidates' final scores. How valid, reliable and fair are the CA scores being used in the assessment process? The continuous assessment in this context refers to the method of ascertaining learners' performance in the cognitive, affective and psychomotor domains through, tests, assignments, projects and other educational activities within a schooling phase (Ben-Yunusa, 2008). This type of CA is a classroom assessment practice that evaluates the students' knowledge, industriousness and character development in the school system. This study focuses on how instructional and assessment practices are influenced by WAEC high-stakes examinations in ten Kaduna State senior secondary schools in Nigeria.

From the bases of secondary education as earlier mentioned, junior school certificate (JSC) is a precondition for one to proceed to the second level of secondary education – the senior secondary school (SSS). This level also lasts for three years with minimum ages between 15 and 18 (see Figure 1.2). The National Policy on Education (FRN, 2013) states that secondary education shall be to prepare the individual for: (a) useful living within the society; and (b) higher education. At the end of this period, students take the Senior School Examination (SSCE) in order to obtain the senior school certificate (SSC). The West African Examinations Council (WAEC) and the National Examinations Council (NECO) presently conduct the West African Senior School Certificate Examination (WASSCE) and the Senior School Certificate Examinations (SSCE), respectively.

Students take the mathematics high-stakes examination at the end of SSS3 and it is expected that they should have demonstrated competencies showing that they have progressed through classroom teachers' instructional and assessment practices to the final year of each tier of secondary education (FRN, 2004). Good classroom mathematics instructional and assessment practices are expected to lead to the production of students who are interested in learning, shun unethical assessment practices and would eventually be successful in high-stakes examinations ( Afemikhe & Omo-Egbekuse, 2010). They should be ready to take their rightful place within the national development agenda as well as being adequately prepared for higher education (Afemikhe & Omo-Egbekuse,

2010; FRN, 2004). Observation shows that these expectations are possibly not being met, as there has been a great public outcry about the quality of senior secondary school products (Musa & Dauda, 2014; Ogundele, Olanipekun & Aina, 2014). This situation calls for investigation into the effects of high-stakes assessment practices on mathematics instructional, preparatory and assessment practices in Nigerian senior secondary schools.

Furthermore, the inclusion of mathematics as a core subject in the secondary school curriculum is due to the key roles mathematics has to play in the achievement of the objectives of the secondary school education, such as promoting of science and technology (Azuka, 2003; Bajah, 2000; Musa & Dauda, 2014; Ukeje, 1977). The provision of trained manpower in the applied sciences, technology and commerce, and the acquisition of appropriate skills, abilities and competence both mental and physical, allow the individual to live on and contribute to the development of his/her society (FRN, 2014). The quality of mathematics education in senior secondary schools is determined by classroom instructional and assessment practices, and high-stakes assessments.

#### **1.4.6 Documents analysis for background information on curriculum and assessment**

To probe and analyse teachers' thinking and reasoning required detailed data collection. Therefore, in addition to the lesson observations and teachers' interviews, archived documents were analysed to assist in clarifying what teachers did in the classroom during the lesson observations and what they said in the interviews. The documents analysed below are the national mathematics curriculum, the WAEC syllabus, two years (2014 and 2016) of Chief Examiner's Reports and samples of May/June WASSCE past questions papers for five years (2013 to 2017).

##### **1.4.6.1 National mathematics curriculum and WAEC syllabus**

The Nigerian Educational Research and Development Council (NERDC) reviewed the senior secondary school mathematics curriculum in 2007. The curriculum adopts a thematic approach with six columns consisting of topics, performance objectives, contents, teaching and learning activities, learning materials and evaluation (NERDC,

2007). It emphasizes entrepreneurial skills and the use of computer skills in mathematics instruction. Therefore, many computer-assisted instructional materials are recommended for instructional practices of the various topics in the mathematics curriculum. Additionally, few introductory topics in matrices, modular arithmetic and simple calculus were included. These topics were formerly restricted to further mathematics, but their inclusion in this curriculum will enhance the competency of students in various fields they will pursue at the tertiary level of education. Table 1.3 presents a summary of the content of the national mathematics curriculum. It has left out columns for performance objectives, teaching and learning activities, learning materials and evaluation, because including those columns will give a volume of over fifty pages.

Table 1.3 The national mathematics curriculum (adapted from (NERDC, 2007).

<b>Content</b>	<b>Sub-content</b>
1. Number and Numeration	a. Logarithm and applications b. Matrices c. Number bases other than 10 d. Modular arithmetic e. Variation f. Surds
2. Algebraic process	a. linear equations b. Quadratic equations and applications c. Algebraic fractions
3. Geometry	a. Mensuration: multiple dimension objects b. Trigonometry c. Plane and coordinate geometry
4. statistics	a. Statistics b. Probability
5. vectors	a. Vectors b. Transformations
6. Introductory calculus	a. Differentiation of polynomials b. Integration of polynomials

Table 1.3 is a modified summary of NERDC (2007) content of the national mathematics curriculum for senior secondary schools in Nigeria. The performance objectives, teaching and learning activities, learning materials and evaluation are not included in the table. Only the contents and subtopics are presented in line with the structure of WAEC syllabus for comparison.

### 1.4.6.2 WAEC mathematics syllabus

The aims of the WAEC syllabus (WAEC, 2015) are to test candidates: (1) mathematical competency and computational skills; (2) understanding of mathematical concepts and their relationship to the acquisition of entrepreneurial skills for everyday living in the global world; (3) ability to translate problems into mathematical language and solve them using appropriate methods; (4) ability to be accurate to a degree relevant to the problem at hand; and (5) logical, abstract and precise thinking. This syllabus is not intended to be used as a speculative teaching syllabus, but as a guide to experts in setting and editing the WASSCE questions. Teachers are advised to use their own national curriculum for their instructional and assessment practices. Table 1.5 presents the contents of WAEC syllabus.

Table 1.4 WAEC mathematics syllabus

Content	Sub-content
A. Number and Numeration	(a) Number bases, (b) Modular arithmetic, (c) Fractions, Decimals and Approximations, (d) Indices, (e) Logarithms, (f) Sequence and Series, (g) Sets, (h) Logical Reasoning, (I) Positive and negative integers, rational numbers, (j) Surds (Radicals), (k) Matrices and determinants, (l) Ratio, Proportions and Rates, (m) Percentages, (n) Financial arithmetic, and (o) Variation
B. Algebraic processes	(a) Algebraic expressions, (b) Simple operations on algebraic expressions, (c) Solution of Linear Equations, (d) Change of Subject of a Formula or Relation, (e) Quadratic equations, (f) Graphs of Linear and Quadratic functions, (g) Linear Inequalities, (h) Algebraic Fractions, (i) Functions and Relations
C. Mensuration	(a) Lengths and Perimeters, (b) Areas, (c) Volumes.
D. Plane geometry	(a) Angles, (b) Angles and intercepts on parallel lines, (c) Triangles and Polygons, (d) Circles, (e) Construction, (f) Loci
E. Coordinate geometry of straight line	Concept of the x-y plane and Coordinates of points on the x-y plane
F. Trigonometry	(a) Sine, Cosine and Tangent of an angle, (b) Angles of elevation and depression, (c) Bearings
G. Introductory calculus	Differentiation of algebraic functions and Integration of simple algebraic functions.
H. Statistics and probability	(a) Statistics (b) Probability
I. Vectors and transformation	(a) Vectors in a Plane, (b) Transformation in the Cartesian Plane

The WAEC syllabus is drawn from the national curriculum prepared by the Nigerian Educational Research and Development Council (NERDC). It is intended to define the scope and set the limits of the examination and to make item writing easier. It was developed by a panel of subject experts including some item writers and teachers, and it precedes item writing. The relationship between the WAEC syllabus and the national curriculum is particularly important, because the WAEC syllabus is what guides item writers in mathematics (Agheti, 2011). However, the national curriculum is broader than the WAEC syllabus and the WAEC syllabus did not capture all that there is in the national curriculum such as topics, performance objectives, contents, teaching and learning activities, learning materials and evaluation.

#### **1.4.6.3 WASSCE Chief Examiner reports**

The structure of the WASSCE Chief Examiner Reports in mathematics is always based on the candidates' strengths and weaknesses in performance, and remedies for the weak performance. It also gives guidelines on what teachers should look out for in their instructional and assessment practices for their students' optimal performance in mathematics WASSCE.

##### **1.4.6.3.1 WAEC's 2014 May/June WASSCE Chief Examiner Reports**

In the 2014 WASSCE the Chief Examiner reported that the standard of the paper compared favourably with those of the previous years and adequately tested the cognitive skills of the candidates. According to the report, the questions were not only well stated, but their requirements were clearly spelt out. The syllabus was also adequately covered (i.e. the questions have content and face validity) and they had no ambiguity. The diagrams were appropriately drawn and clearly labelled. The rubrics were reported to be clearly stated. The marking scheme was also reported to be well drawn up, very comprehensive and generous to the candidates with marks and weight appropriately distributed according to the strength of the answer. It was reported that the candidates' performance was slightly better than the previous year (i.e. in 2013 the percentage pass was 36.59 and in 2014 it was 58.05). However, the candidates' performance in those

areas of the syllabus where their performance had previously been reported as poor did not change.

#### **a) Candidates' strengths in performance**

The Chief Examiner reported that the topics where candidates showed significant strength were surds, simultaneous equations, completing tables of values and drawing graphs of trigonometric functions, statistics and probability, quadratic equations, number bases and sets. It was also reported that the candidates' performance in section A was better than section B.

#### **b) Candidates' weakness in performance**

The Chief Examiner observed that majority of the candidates exhibited significant weakness in translating words problems into mathematical expressions and diagrams. The report also stated that the majority of the candidates did not adhere to the rubrics of the questions, especially regarding the use of calculators and mathematical tables.

Some areas in the syllabus that were also reported to be poorly attempted by the majority of the candidates include geometry (circle theorems and angles on parallel lines), modular arithmetic, manipulation of decimals and fractions, reading and answering questions from graphs, and representation of information in diagrams.

#### **c) Chief Examiner's suggested remedies for the weaknesses**

The chief examiner suggested remedies to address the candidates' weakness in performance in the 2014 WASSCE as follows: (1) Candidates should be taught simple arithmetic without the use of calculators and tables; (2) Candidates should be encouraged to read the questions carefully to understand their requirements before attempting them; (3) Candidates should be led to acquire knowledge of various mathematical concepts and how to apply them to solving problems in everyday living; (4) Teachers and candidates were encouraged to put in more effort to the teaching and learning of geometry and trigonometry; (5) Teachers and candidates were encouraged to cover the syllabus while preparing for the WAEC high-stakes examination; and (6) Teachers were encouraged to participate in the WASSCE main coordination as this would help them improve their

teaching skills. Finally, qualified mathematics teachers should be engaged in the instructional practices of the subject.

#### **1.4.6.3.2 WAEC's 2016 May/June WASSCE Chief Examiner Reports**

In the 2016 WASSCE, the Chief Examiner reported that the standard of the paper compared favourably with those of the previous years and adequately tested the cognitive skills of the candidates. According to the report, the questions were not only well stated, their requirements were clearly spelt out. The syllabus was also adequately covered (i.e. the questions have content and face validity) and they had no ambiguity. The diagrams were appropriately drawn and clearly labelled. The rubrics were reported to be clearly stated. The marking scheme was also reported to be well drawn up, very comprehensive and generous to the candidates with marks and weight appropriately distributed according to the strength of the question. It was reported that the candidates' performance was slightly better than the previous year (i.e. in 2015 the percentage pass was 38.68 and that of 2016 was 65.70). However, there was improvement in candidates' performance in 2016 but this fell to 59.22% in 2017.

##### **a) Candidates' strengths in performance**

The Chief Examiner enumerated areas where candidates showed significant strengths as an ability to: (i) simplify fractions using the concepts of BODMAS; (ii) solve inequalities; (iii) complete table of values for a quadratic relation, drawing the graph of the relation and using it to solve related problems; (iv) construct table of values under a given operation in modular arithmetic and using them to solve related problems; (v) change the subject of a given relation; (vi) construct cumulative frequency tables for a given distribution, drawing an ogive and using it to solve related problems.

##### **b) Candidates' weaknesses in performance**

The Chief Examiner reported that majority of the candidates exhibited significant weaknesses such as difficulty in: (i) recalling and applying circle theorem to solve related problems; (ii) translating word problems into mathematical statements; (iii) using ruler and

a pair of compasses only to construct a trapezium; (iv) Solving problems involving probabilities; and (v) understanding the concept of plane geometry.

### **c) Chief Examiner's suggested remedies for the weaknesses**

The chief examiner suggested remedies to address the candidates' weakness in performance in the 2016 WASSCE as follows: (1) Tuition (teaching) relating to these areas of weaknesses should be thorough; (2) Candidates should be exposed to problem-solving guide lines such as (i) understanding the problem, (ii) developing and carrying out a plan to solve the problem, (iii) checking the answer after solving the problem; (3) Candidates should be encouraged to solve more problems relating to these areas identified so that they can understand the underlying concepts. The Chief Examiners for mathematics suggested that teachers should give equal attention to all the topics in the syllabus and stop specializing in teaching only some topics. They also recommended that candidates should be given more exercises to practice.

The 2014 and 2016 Chief Examiner's reports have shown the students' strengths and weaknesses in performance, the suggested remedies for both teachers and students, and provided guidelines on what teachers should look out for in their instructional and assessment practices for their students' optimal performance in mathematics WASSCE.

#### **1.4.6.3.3 May/June WASSCE question papers in mathematics from 2013 to 2017**

This subsection analyses five years May/June WASSCE question papers in mathematics from 2013 to 2017. The essence of this analysis was to see how the mathematics curriculum content is reflected in the questions asked as proposed by Bloom's taxonomy of educational objectives, which emphasized testing of students' factual knowledge and metacognitive knowledge (Bloom *et al.*, 1956; Krathwohl, 2002) of mathematics.

Table 1. 5 May/June WASSCE question papers in mathematics from 2013 to 2017

Question number	2013	2014	2015	2016	2017
1	NN	NN/G	AP/SP	NN	NN
2	AP/NN	NN	AP/G	NN	AP/G
3	AP	NN	G	G	G
4	G	G	AP/G	SP	NN
5	G	SP	G	G	NN/SP
6	AP/NN	AP/NN	NN/AP	G	NN
7	AP/G	T	AP	AP/G	G
8	AP/G	NN/AP	G	G/AP	AP/SP
9	G	NN/G	NN	SP	G
10	G	AP/G	GA	G	G
11	SP/G	SP	AP/G/NN	AP/G	NN/G
12	G	T	G	G	AP/NN
13	G	VT	SP	G/NN	NN/AP/IC

NN = Number and Numeration, AP = Algebraic processes, G = Geometry, SP = Statistics and probability, IC = Introductory calculus and VT = Vectors and transformation

Table 1.5 shows the contents of questions from 2013 to 2017 (5 years) May/June WASSCE were adequately spread from the content of the mathematics curriculum and the WAEC syllabus, except vectors and transformation (VT) and introductory calculus (IC), which appeared only in 2014 and 2017 respectively. The essence of this analysis was to see how the contents of the curriculum/WAEC syllabus are always reflected in the actual questions set in WAEC high-stakes examinations in mathematics WASSCE. The analysis shows how these questions were spread across content domains according to Schoenfeld's assessment framework, Popham's instructional and assessment practices, and Bloom's taxonomy.

#### 1.4.7 Kaduna State senior secondary schools, Nigeria as the study area

Kaduna state is the study area where the ten senior secondary schools were selected. It is located in the north-west geo-political region of Nigeria (FRN, 2004). Kaduna is one of the 36 states of the country. Kaduna State is divided into 23 local government areas politically and has nine ministries. One of these is the Ministry of Education, Science and

Technology, which manages the activities of education, subdivided into 12 zonal inspectorate divisions. Each zonal office oversees the educational activities within its own jurisdiction. Specifically, the zonal offices control the secondary schools within their areas. The ten senior secondary schools sampled are within three zones: Godogodo zone (School A), Kafanchan zone (Schools B, C, D, E and F) and Zonkwa zone (Schools G, H, I and J).

The secondary schools are divided into junior secondary schools and senior secondary schools (FRN, 2014). The junior secondary school lasts for three years, that is, junior secondary school JSS1, JSS2 and JSS3, which is the foundation for senior secondary education. The senior secondary school education also lasts for three years (SSS1, SSS2 and SSS3). The SSS3 was chosen for this study because it is the graduating class that writes the WAEC high-stakes examinations. Every class in the level of secondary education has its own mathematics curriculum and cannot be compared directly. Adding any class that does not sit for any high-stakes assessments is not reflective of this study and the scope may be very wide and complex. There are 314 senior secondary schools in Kaduna State and ten were selected for the qualitative ethnographic case study.

The academic calendar for Kaduna state senior secondary schools is three terms annually. The first term is from September to December, the second term is from January to April and third term from May to August. There are vacations in between the three terms annually. There is inconsistency on the dates of resumption, dates of departure for vacations and periods of terminal break. End-of-term examinations are written at the end of each term and the third term examinations are the promotion examinations, where those who pass are promoted to the next class. The third term examinations for the SSS3 is the WAEC high-stakes examinations. This is the time when SSS3 students write the May/June WASSCE in Nigeria. All the assessments during the term and the end of term examinations for SSS1, SSS2 and SSS3 cumulatively form the 20% CA scores used by WAEC as part of the total scores for mathematics in the WASSCE (WAEC, 2014). The CA practices and challenges within the school system and at WAEC high-stakes examinations form part of this study. The research aims and objectives can be achieved, and the research questions can be answered, only after proper exploration of the senior

secondary school mathematics teachers instructional, preparatory and assessment practices in the ten Kaduna State senior secondary schools.

### **1.5 Aims and objectives of the study**

The aim of this study was to investigate the effect of high-stakes assessments on the instructional practices of selected mathematics teachers in Kaduna State (Nigeria) senior secondary schools. Specifically, the objectives of the study were:

1. To identify the effect of WAEC high-stakes examinations on teaching strategies for mathematics in senior secondary school classrooms;
2. To examine the effect of the WAEC high-stakes examinations on teachers' beliefs about what it means to teach mathematics effectively;
3. To analyse the opportunities and challenges faced by senior secondary school mathematics teachers and WAEC in high-stakes continuous assessment practices.

### **1.6 Research questions**

The main research question is: What are teachers' instructional practices in preparation for high-stakes mathematics assessments in Nigerian senior secondary schools?

The sub-questions are as follows:

- a. What are the effects of WAEC high-stakes examinations on mathematics instructional practices and strategies in selected Kaduna State senior secondary school classrooms?
- b. What is the effect of high-stakes examinations on the Kaduna State mathematics teachers' beliefs about what it means to teach mathematics effectively?
- c. What are the opportunities and challenges faced by senior secondary school mathematics teachers and WAEC in high-stakes continuous assessment practices?

## 1.7 Significance of the study

This qualitative ethnographic case study provided an opportunity to observe and investigate the influence of WAEC high-stakes examination on the Kaduna State senior secondary school teachers' instructional practices. The influence include: the types of instructional and preparatory strategies, mathematics content focus, teachers' beliefs about effective teaching of mathematics, continuous assessment practices and all other actions in the classroom. It is the researcher's intention that this study of effect of high-stakes assessments on instructional practices of selected mathematics teachers in Nigerian senior secondary schools will provide in-depth insights into effective mathematics instructional practices and appropriate assessment practices of senior secondary school students for improved performance in WAEC high-stakes examinations (WASSCE) in Nigeria. It is also hoped that this study will enhance and improve the performance of Nigerian high-stakes assessment agencies in conducting these time-restricted examinations.

Assessment practices are based on teacher beliefs, knowledge and skills in educational assessment (Pajares, 2002). Understanding teachers' classroom instructional practices and high-stakes assessments provides important information for educational decisions that can be made about students' performance in mathematics (Agheti, 2011; Lamidi, 2013; Ogundele, Olanipekun & Aina, 2014). The results of this study may provide valuable insights for understanding mathematics teachers' instructional, preparatory and assessment practices and give an indication of the professional support needs of teachers in Nigeria and other parts of the world.

Information obtained in this study may also be used for decision making such as evaluating the effectiveness of classroom and high-stakes assessment practices that teachers adopt as they evaluate student learning. Findings from this study can also add to the body of knowledge about existing instructional and assessment theory and practice within the Nigerian education system and act as a framework for initial teacher education and continuing professional development in the use of classroom assessments.

This study can inform teachers, principals of senior secondary school, policy makers and other stakeholders in education about the adopted moderation methods use by WAEC high-stakes examination in the WASSCE in combining school-based CA scores and WASSCE scores. This will enlighten those teachers and principals of senior secondary school who have developed an interest in arbitrary faking and/or inflating their students' CA scores and make them aware of the washback effects of this on the school and their students.

### **1.8 Ethical issues**

The researcher sought ethical clearance from the Research Ethical Committee (REC), Humanities, Stellenbosch University, through the Department of Curriculum Studies, Faculty of Education, and Stellenbosch University, South Africa, to carry out the research. The researcher also requested a research permit from Kaduna State Ministry of Science, Technology and Education from the state zonal inspectorate offices and the selected schools. The permit legally allowed the researcher to conduct the research. During the research process, the participants were assured of confidentiality of information given. The ethical issues of informed consent, avoidance of deception, maintaining confidentiality, anonymity and privacy, and caring (Christians, 2000; McMillan & Schumacher, 2006) were addressed according to the ethical code of Stellenbosch University; hence the ethical conditions and considerations were fulfilled during this research (see section 4.10 for detail).

### **1.9 Delimitations and key assumptions**

This study only focuses on how mathematics teachers' instructional, preparatory and assessment practices are influenced by WAEC high-stakes assessments in Nigerian senior secondary schools. It does not include the students' learning perspectives and only mathematics teachers teaching the graduating class, which is the SSS3 students in ten public schools in Kaduna State, were used for the study. Kaduna State is located in the north-west geopolitical zone of Nigeria. This study was an ethnographic case study of ten mathematics teachers and can thus not be generalized to a larger population. It can possibly be generalized to the level of theory and practice of education. However, the

data from this study might be valuable to the Kaduna State senior secondary schools. Nonetheless, the goal of this study was not to generalize about mathematics teachers' instructional and assessment practices, their beliefs about what it means to teach mathematics effectively, and opportunities and challenges faced by Kaduna State senior secondary schools and WAEC high-stakes examinations in CA practices. Falk and Guenther (2010) caution that qualitative research is not done for the sake of generalization, but there are plenty of reasons to apply it in theory and practice of education. To mention a few, qualitative research is used to produce evidence based on the exploration of specific contexts and individuals (Holloway, 1997).

The study assumed that all students can learn mathematics when it is effectively taught and meaningfully learnt, and the students are treated equitably, recognizing the individual differences that distinguish one student from another and considering these differences in their instructional practices. Teachers' belief is that mathematics should be taught in a natural setting considering the complexity of the school systems. However, some teachers assumed that their role in mathematics instruction is to facilitate learning.

It was also assumed that the classroom culture would entail multiple preparatory strategies during the lesson observations. The purposive sample chosen was salient enough to support an accurate and complete interpretation of the culture of the mathematics classroom. Assumptions for this study were influenced by Popham's framework of instructional and assessment practices, Schoenfeld's framework of teaching for robust understanding, and Bloom's taxonomy of educational objectives. Assumptions in qualitative research influenced all aspects of the researcher focus – the way the study was designed, conducted, analysed and interpreted (Bryman, 2012; Denzin & Lincoln, 2011).

It is therefore, expected that the readers will encounter similar situations and judge the relevance of the information that will be produced according to their own circumstances.

## **1.10 Referencing method**

The American Psychological Association (APA) (sixth edition) referencing method was adopted in preparing this dissertation. Citations in the text and references are arranged and listed in alphabetical order.

### **1.11 Definition of key terminology**

The key terms that are used in this research are explained below.

#### **Assessment**

Assessments are tests, assignments, practical, projects and any task set and administered for students by the classroom teachers and other high-stakes examination bodies/agencies in order to determine the level of students' achievement or performance in mathematics.

#### **Assessment practices**

Assessment practices are the deliberate attempts of the classroom teachers and high-stakes examination bodies to measure and evaluate the impact of the instructional process and the overall effect of school learning on the students' achievement.

#### **Common content knowledge**

Common content knowledge is the mathematical knowledge and skills that teachers use for memorizing solution procedures to arrive at accurate answer in a mathematics problem.

#### **Conceptual understanding**

Conceptual understanding is the successful understanding of mathematical ideas and the ability to transform the knowledge into new situations and apply it to new contexts.

#### **Continuous assessments (CA)**

Continuous assessment is a method of ascertaining what a student gains from schooling in terms of knowledge, industry, and character development, considering all one's performance in tests, assignments, projects and other educational activities during a given period of term, year or during the entire period of an educational level.

**High-stakes assessments**

High-stakes assessments are those standardized tests or examinations administered at the end of every level of education (from nursery/primary to senior secondary school equivalent from Grade 1 to 12) in order to make significant educational decisions about the pupils/students, teachers and the schools (Aysel, 2012; Smyth, Banks & Calvert, 2011). These assessments also determine students' graduation, selection and placement into higher level of education institutions.

**Mathematics instructional practices**

This refers to the classroom interactions between teachers and students around the content of the mathematics curriculum directed toward facilitating students' achievement of set learning goals (Hiebert & Grouws, 2007).

**Mathematical knowledge for teaching (MKfT)**

MKfT refers to the mathematical knowledge that is used in the classroom, consisting of subject matter knowledge (SMK) and pedagogical content knowledge (PCK).

**Mathematics teachers' beliefs**

Mathematics teachers' beliefs is a conception of several dimensions related to mathematics education and teaching, curricula and the teaching profession in general, and the educational culture which affects instructional practices of mathematics.

**Pedagogical content knowledge (PCK)**

PCK refers to the teacher's knowledge of subject matter as well as knowledge of the principles and practice of teaching (i.e. teachers' content knowledge of mathematics and how to effectively teach the content).

**Revision practices**

Revision practices are those strategies or approaches employed by mathematics teachers in preparing their students for both classroom and high-stakes assessments.

**Teacher**

A teacher is a knowledgeable individual who assists the learner to acquire a conceptual understanding of mathematics through effective instructional practices. He/she helps the

students to make sense of content of mathematics by engaging students in meaningful learning of mathematics in the classroom.

### **Teacher's knowledge**

Refers to the teacher's awareness, or understanding, of a circumstance or fact, which is gained through association or experience, books, media, encyclopaedias, academic institutions, and other sources.

### **Teacher's knowledge and skills**

Refers to the teacher's awareness, or understanding, of a circumstance or fact, and their ability to use and/or to apply that awareness, or understanding, of a circumstance, or fact, in context.

### **Teachers' pedagogical knowledge**

Refers to the specialised knowledge possessed by mathematics teachers that is aimed at facilitating effective teaching and meaningful learning environments for all the students.

### **Teacher's pedagogical skills**

Refers to the teacher's ability for planning and making learning opportunities accessible to all learners as well as teacher's ability to assess students' learning.

### **WAEC high-stakes examinations**

This refers to standardized examinations conducted by West African Examination Council for the five Anglophone (English-speaking) countries in West Africa.

### **WAEC high-stakes mathematics examinations (WASSCE in mathematics)**

These are those standardized mathematics West African Senior School Certificate Examinations administered by WAEC at the end of senior secondary education.

### **1.12 Outline of the thesis chapters**

This study investigates the effect of high-stakes assessments on mathematics teachers' instructional and assessment practices in selected Nigerian senior secondary schools. The main idea here is to highlight for teachers and stakeholders in education the current

instructional and assessment practices of selected mathematics teachers in Kaduna State senior secondary schools. This study also investigates the fairness of CA practices both in the classroom and in the WAEC high-stakes examination as well as mathematics teachers' beliefs, opportunities and challenges faced in their instructional and assessment practices.

This thesis is comprised of six chapters: the orientation and motivation/rational chapter, followed by Chapters 2, 3, 4, 5 and 6. Figure 1.3 summarizes the research structure and the aspects that are dealt with in each chapter.

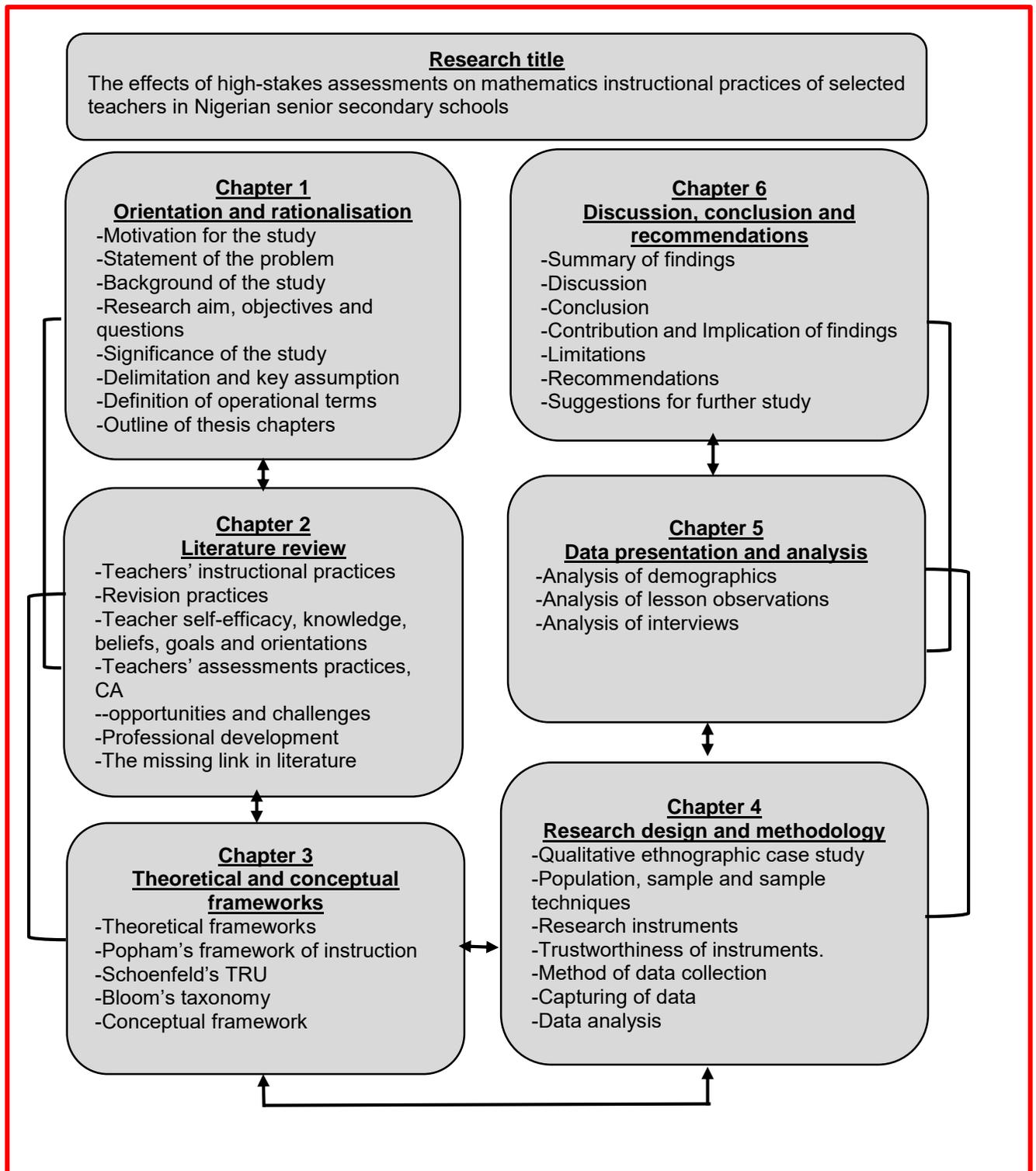


Figure 1.3: Summary of the research study

Chapter 1 provides the introduction, motivation and rationale for this study. It also discusses how the mathematics teachers' instructional and assessment practices are crucial in Nigerian senior secondary schools and the high-stakes assessments. The history of Nigerian education, post-independence mathematics curriculum and curriculum reforms, assessment practices, history of West African Examination Council (WAEC), organization and administration of education in Nigeria and the importance of mathematics in the Nigerian secondary school curriculum are highlighted. This chapter also presents a documentary analysis of the official documents requested from the ten senior secondary schools. The researcher explains the ethical issues that are significant for this study. The chapter includes discussion of the referencing method, the definition of key terminology, the conclusion and the overview of the thesis chapters.

Chapter 2 reviews related literature that forms the theoretical basis for this study. It gives an overview of mathematics teachers' instructional and assessments practices as well as mathematics teachers' knowledge, beliefs, self-efficacy and fairness of assessment practices in the high-stakes assessments, mathematics teachers' professional development and the missing link in the literature.

Chapter 3 gives the theoretical and conceptual frameworks of the study. The theoretical frameworks are underpinned by Popham's framework of instructional and assessment practices, Schoenfeld's framework of teaching for robust understanding, and Bloom's taxonomy of educational objectives framework. The three frameworks focus on students' conceptual understanding of senior secondary school mathematics. The conceptual framework is a model whereby the researcher presents the relationships between independent and dependent variables, and other related concepts in the study.

In Chapter 4 the various designs and research methods employed during this study are explained. The chapter gives an overview of a qualitative case study, ethnographic approach, research instruments such as mathematics teachers' lesson observations, interviews and archive documents analysis, and the use of field notes and video recordings. This chapter also gives reasons for using interviews and lesson observations as methods for data collection and how the methods were used. The chapter concluded

by explaining the ethical considerations and the entire procedure for data collection and analysis of this study.

Chapter 5 of this study gives a detailed presentation of the analyses of the field work as well as interprets the findings. The results of the lesson observations, interviews and examination of the archive documents were analysed. It summarizes the research findings, and interpretation of results, focusing on how the results provide answers to the research questions asked and reflecting on the theoretical frameworks and the range of literature that was reviewed.

Chapter 6 draws the conclusions, focusing on the summaries of Chapter 1 to 5, and the summary of the findings. Conclusions are drawn to give an overall picture of the current situation regarding the effect of WAEC high-stakes examinations on mathematics teachers' instructional practices, mathematics teachers' beliefs, opportunities and challenges faced by senior secondary school mathematics teachers and WAEC high-stakes examination in their CA practices. The researcher draws conclusions based on the findings and points out a number of implications, the contribution to knowledge in this field, and makes recommendations based on the research results as well as providing suggestions for further studies.

### **1.13 Conclusion**

This chapter gives an overview of the orientation and motivation for the study. The motivation and rationale were briefly discussed, as were the background and purpose of the study; the research questions were highlighted as well as the delimitation, ethical issues, significance of the study, definition of key terms, amongst others. For Nigeria senior secondary school students, the aim of learning mathematics emphasizes and focuses solely on passing high-stakes examinations (WASSCE, SSCE, etc.). It is pertinent to note that an effective mathematics instructional practices impart to the students' knowledge and skills for functional living, sense making and enhance prospects for students' success in high-stakes examinations. The next chapter reviews the literature relevant to the study.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter reviews the relevant literature on how mathematics teachers' instructional, preparatory and assessment practices in Kaduna State senior secondary schools are influenced by high-stakes assessments. It also reviews the mathematics curriculum, teachers' knowledge, beliefs, self-efficacy and professional development as variables, which influence goal setting and persistence of effort as well as the effectiveness of teachers' instructional, preparatory and assessment practices in the school system and for high-stakes assessments. The purpose of the review is to establish what is already known about these issues and to identify gaps in the literature.

#### 2.2 Mathematics teachers' instructional practices

The success of senior secondary school students in high-stakes assessments is determined not only by the mathematics curriculum content and materials, but also by the effectiveness of the mathematics teachers' instructional practices (Brophy, 1991). Students are expected to achieve more in the mathematics classrooms, where they spend quality time being taught and supervised by their teachers. Ogunkunle (2007) argues that Mathematics teachers have adopted the chalk-and-talk (traditional) methods at senior secondary school level. The use of chalk-and-talk methods has become burdensome and a concern in Nigerian senior secondary schools, because it does not establish strong connections between the mathematics concepts learnt in the classroom and their application to real-life situations, hence, denying students meaningful learning. However, the teaching of mathematics in this century means more than finding applications to real life. The instructional practices in the 21<sup>st</sup> century demands that mathematics teachers are grounded with mathematical knowledge for teaching (MKfT) and can teach mathematics for robust understanding and enable equitable access to legitimate mathematical knowledge for all students (Schoenfeld 1992, 2017). The mathematics content, and the instructional and assessment practices as established by the NERDC (1992, 2007) were changed from the traditional curriculum and strategies of

teaching mathematics for meaningful learning, but have reduced to the traditional lecture method that makes students passive recipients of knowledge and skills. Students are supposed to be actively involved in the mathematics teaching/learning process that engages them in multiple solution strategies.

However, the nature of mathematics instructional practices affects the nature and level of students' learning of mathematics (Hiebert & Grouws, 2007). Such a claim seems obvious and it is possible to name some mathematics teachers who were effective in their mathematics instructional practices. Those teachers made a difference because of their instructional practices in mathematics and some of the literature suggests that different teachers produce different levels of student performance (Nye, Konstantopoulos, & Hedges, 2004; Sanders, & Rivers, 1996; Sanders, Saxton, & Horn, 1997). Therefore, the length of time taken and the supervision given are expected to contribute towards helping the senior secondary school students to acquire basic knowledge in mathematics and eventually make them perform well in any high-stakes assessments.

As a focal point and unit of analysis in this study, it is necessary to define the term 'instructional practices'. Cohen, Raudenbush and Ball (2003, p. 122) state that "mathematics instruction consists of interactions among teachers and students around content" of the mathematics curriculum in the school system. Similarly, Morrow (2007), and Hiebert and Grouws (2007) define instructional practices as classroom interactions between teachers and students around the content of the curriculum directed toward facilitating students' achievement of learning goals. These definitions are offered in the context of all the subjects in the curriculum (including mathematics). Practices in this context refer to familiar mathematical activities regularly done by mathematics teachers in the school, while instruction is the mathematics teaching/learning process.

Instructional practices in senior secondary school mathematics are the actions and discourses that transpire in the course of a lesson (Westbrook, Durrani, Brown, Orr, Pryor, Boddy & Salvi, 2013). This is a situation where both the teacher and the students are actively engaged with mathematics. Taking a cue from Alexander (2000), instructional practices consist of: (1) teacher oral discourse and visual representation to convey or construct the new knowledge being presented or indicated to the students; (2) the setting

up of tasks in which students can interact with new content and/or develop tactile skills; (3) a range of teacher-student and student-student interactions in which language is key to individual learners, as pairs, small groups or whole groups; and (4) a teacher's monitoring, feedback strategies, intervention strategies, and both formative and summative assessment of the students' work, including peer assessment by the learners. This suggests a true picture of mathematics instructional practices within a standard setting in the senior secondary school system.

The crucial challenge is to understand what factors make mathematics teachers effective in a high-stakes examination environment? This question does not have an obvious answer. The focus of this study may shed more light on this question. Meanwhile, the effectiveness of a teacher affects the amount of learning that takes place in the classroom. Good and Grouws (1977) study the effectiveness of teachers' instructional practices in a 4<sup>th</sup> grade mathematics classroom. The findings reveal that the effective teachers consistently produce higher achievers in mathematics than the less effective teachers. In their assessment, the effectiveness of a teacher is based on certain qualities exhibited by the teacher during instruction. These qualities are: (a) clarity of instruction devoid of ambiguity, (b) time spent on content preparation, (c) teachers' expectation of students' achievement, and (d) task-focused environment. Therefore, it is very important for senior secondary schools in Nigeria to have a calibre of teachers with the ability to handle the mathematics content effectively, where teachers will teach mathematics with conceptual understanding and procedural knowledge of mathematics.

Iji and Harbor-Peter (2005) observe that mathematics teachers in Nigeria still use traditional methods in their instructional practices that adopt whole-class, teacher-centred and lecture-based instruction that does not allow for students' interaction. Even if the traditional lecture method is not supporting students' interests nor positive outcomes in senior secondary school mathematics in the classroom and at the high-stakes assessment level, teachers still adopt such strategies in their instructional practices. Iji and Harbor-Peter (2005) were supported by Achor, Imoko and Jimin (2012), who lament that the unfavourable situation requires the training of more mathematics teachers at both pre-service and in-service stages to introduce alternative teaching strategies that go

beyond the traditional pedagogy of one teacher per class, such as collaboration or team teaching, group instructions and all other instructional practices that are student-centred and emphasize conceptual understanding of the students.

Although, mathematics instructional practices are filled with complex dynamics, evidence demonstrates students' achievement through their conceptual understandings and procedural knowledge (Hiebert & Grouws, 2007). Learners show conceptual understanding in the mathematics classroom when they can provide evidence that they can recognize, label and generate examples of concepts; apply and interrelate solution strategies, diagrams, manipulatives, and a variety of concept representations; identify and use principles; recall and use appropriate facts and acceptable definitions; compare and contrast related mathematical concepts and principles; and identify/recognize, interpret and use the symbols, terms and signs used to represent mathematical concepts (Krathwohl, 2002). Successful teachers' instructional practices are those that lead to students' conceptual understanding of mathematical ideas and an ability to transfer their knowledge into new situations and apply it to new contexts. When senior secondary school students acquire such competencies from their teachers' instructional practices, they can successfully attempt any mathematics question during the WAEC high-stakes examinations.

Students demonstrate procedural knowledge in mathematics when they can select and apply appropriate procedures correctly; verify or justify the correctness of a procedure using concrete models or symbolic methods; or extend or modify procedures to deal with factors inherent in problem settings (Battista, 1999; Koloï-Keaikitse, 2012). Procedural knowledge encompasses the abilities to read and produce graphs and tables, execute geometric constructions, and perform non-computational skills such as rounding and ordering mathematical values. Procedural knowledge is often reflected in a student's ability to connect an algorithmic process with a given problem situation, to employ that algorithm correctly, and to communicate the results of the algorithm in the context of the problem setting. This aspect of the ability is fundamental for senior secondary school students in following meaningful procedures and arriving at the accurate answer to any given question in WAEC's WASSCE in mathematics.

Romberg (2000) outlines basic assumptions related to the instructional practices in a functional education system as: (1) all students must have an opportunity to learn new mathematics; (2) all students have the capacity to learn more mathematics; (3) new applications and changes in technology have altered the importance of some mathematics concepts; (4) new instructional environments can be created using technological tools; and (5) meaningful mathematics learning is a product of purposeful engagement and interaction which builds on prior experience. If these assumptions are acknowledged by mathematics teachers, they can improve their instructional practices for optimal performance of senior secondary school students in high-stakes assessments. Hence, the lesson observations in this study gave an overview of mathematics teachers' interactions with the Kaduna State senior secondary school students and how their mathematics instructional, preparatory and assessment practices are influenced by high-stakes assessments.

Ball et al. (2008) identify some common areas of agreement about mathematics education as they relate to mathematics instructional practices based on some fundamental premises. These areas of agreement include: (a) mathematical fluency requires automatic recall of certain procedures and algorithms; (b) use of calculators in instruction can be useful but must not impede the development of fluency with computational procedures and basic facts; (c) using and understanding the basic algorithms of whole number arithmetic is essential; (d) developing an understanding of the number meaning of fractions is essential; (e) teachers must ensure that the use of "real-world" contexts for mathematics instruction maintains a focus on mathematical ideas; (f) mathematics should be taught using multiple strategies, but the teacher needs to handle selection of strategies appropriately for a specific concept; and (g) mathematics teachers must understand the underlying meaning and justifications for ideas and be able to make connections among topics in the mathematics curriculum. These areas of agreement are vital to constructive mathematics instructional practices. This could be an effective guide to standards-based mathematics instruction for optimal performance of Nigerian senior secondary school students in WAEC high-stakes mathematics examinations – the WASSCE.

Best practices in mathematics instruction and effective assessment practices are essential to support and improve senior secondary school students' performance in the WASSCE mathematics high-stakes examinations conducted by WAEC (Abass, 2000). Mathematics teachers and students at Nigerian senior secondary schools are under tremendous pressure from policy makers and stakeholders in education to account for student performance in classroom and high-stakes assessments (Sani, 2015). Despite these pressures, mathematics teachers should not be influenced by the results of high-stakes assessments only to measure students' performance in mathematics. They should strive to engage students in meaningful mathematics learning first and foremost.

Teese (2000) poses this question: Does success in the mathematics examination simply mean the sum of mathematics ability and good teaching? He further thinks that it is something more than that because students with credits in mathematics are expected to have mathematics proficiency and should be able to apply mathematics in real-life contexts. The mathematics teacher should be seen teaching mathematics for conceptual understanding (Popham, 2001, 2003b, 2004; Schoenfeld, 1992, 2016, 2017a) and not only for success in high-stakes assessments. However, in this era of passion for success in high-stakes assessments, senior secondary school students are taught mathematics in a way which means they rely heavily on memorization and manipulative techniques to pass high-stakes examinations without proper emphasis on conceptual understanding – let alone applying the knowledge or techniques in new situations.

The following best practices for implementing effective mathematics lessons as outlined by Teaching Today (2005b p. 7) should be followed: (a) students' engagement is at a high level; (b) tasks are built on students' prior knowledge; (c) scaffolding takes place, making connections to concepts, procedures and understanding; (d) high-level performance is modelled; (e) students are expected to explain their thinking and meaning; (f) students self-monitor their progress; and (g) proper time is devoted to tasks. Although this is an American policy on education, most of their best practices are similar to the ones stated in the Nigerian national policy on education. In this case, mathematics teachers and students in Nigeria senior secondary schools are expected to implement them in their mathematics classrooms instructional and assessment practices (FRN, 2004). Applying

these principles of best practice in instructional methods will improve students' knowledge and skills, and enhance the prospects for students' success in the high-stakes assessments in the school system.

This brief review of the literature related to mathematics instructional practices shows that there have been studies of best practices for use in mathematics instruction. These recommended practices are summarized in Table 2.1 by The Education Alliance (2006), an American education policy that outlines instructional elements and recommends instructional and assessment practices in mathematics.

Table 2.1: Instructional elements, recommended instructional and assessment practices in mathematics (adapted from The Education Alliance, 2006)

Instructional element	Recommended practices
<b>Curriculum Design</b>	<ul style="list-style-type: none"> <li>• Ensure mathematics curriculum is based on challenging content</li> </ul>
	<ul style="list-style-type: none"> <li>• Ensure curriculum is standards based</li> </ul>
	<ul style="list-style-type: none"> <li>• Identify skills, concepts and knowledge to be mastered</li> </ul>
	<ul style="list-style-type: none"> <li>• Ensure that the mathematics curriculum is vertically and horizontally articulated</li> </ul>
<b>Professional Development of Teachers</b>	Provide professional development which focuses on:
	<ul style="list-style-type: none"> <li>• Knowing/understanding standards of mathematics teachers' proficiency</li> </ul>
	<ul style="list-style-type: none"> <li>• Using standards as a basis for instructional planning</li> </ul>
	<ul style="list-style-type: none"> <li>• Teaching using best practices</li> </ul>
	<ul style="list-style-type: none"> <li>• Multiple approaches to assessment</li> </ul>
	<ul style="list-style-type: none"> <li>• Develop/provide instructional support materials such as curriculum maps and pacing guides</li> <li>• Establish mathematics leadership teams and provide mathematics coaches</li> </ul>
<b>Technology</b>	<ul style="list-style-type: none"> <li>• Provide professional development on the use of instructional technology tools in the classroom by teachers</li> </ul>
	<ul style="list-style-type: none"> <li>• Provide access to a variety of technology tools as instructional materials</li> </ul>
	<ul style="list-style-type: none"> <li>• Integrate the use of technology across all mathematics curricula and courses</li> </ul>

<b>Manipulatives</b>	<ul style="list-style-type: none"> <li>• Use manipulatives to develop understanding of mathematical concepts</li> </ul>
	<ul style="list-style-type: none"> <li>• Use manipulatives to demonstrate word problems</li> </ul>
	<ul style="list-style-type: none"> <li>• Ensure use of manipulatives is aligned with underlying mathematics concepts</li> </ul>
<b>Instructional Practices</b>	<ul style="list-style-type: none"> <li>• Focus lessons on specific concept/skills that are standards based</li> </ul>
	<ul style="list-style-type: none"> <li>• Differentiate instruction through flexible grouping, individualizing lessons, compacting, using tiered of classroom structure.</li> </ul>
	<ul style="list-style-type: none"> <li>• Assignments and varying question levels.</li> </ul>
	<ul style="list-style-type: none"> <li>• Ensure that instructional activities are learner-centred and emphasize inquiry/problem-solving</li> </ul>
	<ul style="list-style-type: none"> <li>• Use experience and prior knowledge as a basis for building new knowledge</li> </ul>
	<ul style="list-style-type: none"> <li>• Use cooperative learning strategies and make real life connections</li> </ul>
	<ul style="list-style-type: none"> <li>• Use scaffolding to make connections to concepts, procedures and understanding</li> </ul>
	<ul style="list-style-type: none"> <li>• Ask probing questions which require students to justify their responses</li> </ul>
	<ul style="list-style-type: none"> <li>• Emphasize the development of basic computational skills</li> </ul>
<b>Assessment</b>	<ul style="list-style-type: none"> <li>• Ensure assessment strategies are aligned with standards/concepts being taught</li> </ul>
	<ul style="list-style-type: none"> <li>• Evaluate both student progress/performance and teacher effectiveness</li> </ul>
	<ul style="list-style-type: none"> <li>• Utilize student self-monitoring and peer evaluation techniques</li> </ul>
	<ul style="list-style-type: none"> <li>• Provide guided practice with feedback</li> </ul>
	<ul style="list-style-type: none"> <li>• Conduct error analyses of student work</li> </ul>
	<ul style="list-style-type: none"> <li>• Utilize both traditional and alternative assessment strategies</li> </ul>
	<ul style="list-style-type: none"> <li>• Ensure the inclusion of diagnostic, formative and summative strategies</li> </ul>
	<ul style="list-style-type: none"> <li>• Increase use of open-ended assessment techniques</li> </ul>

The instructional elements in Table 2.1 recommended and provided the mathematics teachers the guidelines for effective instructional, preparatory and assessment practices

for excellent performance in WAEC high-stakes examinations in Nigerian senior secondary school students. Instructional technology needs to be integrated into mathematics instructional practices across all mathematics curricula and courses in Nigerian senior secondary schools, as stated in the Nigerian mathematics curriculum (NERDC, 2007) and the Nigerian national policy of education (FRN, 2004). The professional development of mathematics teachers will also improve and update their knowledge for implementing best instructional and assessment practices.

Mitchell (2006) reviewed the literature on high-stakes examinations and their effects on instructional practices. For example, on the one hand, teachers believed that high-stakes examinations narrow the curriculum down to teaching only those topics in mathematics that are likely to appear in the examinations. Teachers felt compelled to encourage their learners to resort to memorisation of solution procedures and sacrifice higher-order critical thinking skills and they emphasized test preparation at the expense of holistic mathematics learning for knowledge and skills (Popham, 2001a; Stecher, 2002; Yeh, 2005). On the other hand, teachers believed that examinations can motivate them to work harder and help them to diagnose students' learning difficulties (Baker, 2004; Langer, 2001; Yeh, 2005). There could be some similarities to teacher practices and beliefs in the Nigerian context.

For senior secondary school mathematics teachers to address the problem of students' achievement in mathematics, they should integrate different instructional strategies and instructional materials into their classroom instructional practices. Attribute of these instructional strategies are the presentation, practice of taught mathematical concepts and teaching of mathematics content of previous examinations as in examination driven instruction (Julie, 2013a; Julie *et al.*, 2016). However, Popham's (2001, 2003a) instructional and assessment practices like Schoenfeld's (1992, 2016, 2017a), emphasize that mathematics teachers' instructional and assessment practices should be geared toward teaching for robust understanding in mathematics, and challenging and engaging students with mathematics tasks in the classrooms.

There is a belief that massed practice (practising a task continuously without rest or a break) is inefficient, perhaps because it overloads the students' cognitive resources

(Smith & Rothkopf, 1984). Therefore, teachers should be careful not to overload the students with work in the classroom. Smith and Rothkopf (1984) confirm the belief that massed practice in diverse environmental contexts of teaching, and also providing the contextual aids for the organization of course content, can make instruction more effective. These predictions were tested with an eight hours' statistics course, consisting of four videotaped lessons. The two presentations were between one-day mass practice and four days distributed practice, in a single classroom and diversified by repeating the lesson in four different classrooms. The retention level was tested on the fifth day. It was revealed that the distribution of lessons over four days was more effective than over the single day, and also that diversification of context by using different classrooms for each of the four lessons improved performance.

Julie *et al.* (2016) report on the effect size of an intervention on Grade 12 students' achievement in mathematics when a distributed practice and spiral revision approaches were used. Effect size is an important measure used to ascertain whether an intervention or project for improvement of teaching of mathematics has been effective or not (Julie *et al.*, 2016). The spiral revision was to address unsatisfactory performance in the National Senior Certificate (NSC) mathematics examination in the Western Cape Province of South Africa. Only 32% of the learners obtained a pass level of 30% and higher for the topics that focus on in the June examination. This percentage increased to 60% after the intervention. The mean percentage score for the June examination was 27.15 and it increased to 37.97 for the September examination. Therefore, the effect size was high and there was improvement in students' motivation level for mathematics. The study recommended that more attention be accorded to the mathematics teaching strategies not only in a high-stakes context but also for life skills.

Aysel (2012) explored Irish and Turkish teachers' views on high-stakes examinations, test preparation practices and classification of the questions of recently conducted examinations. Irish teachers seemed to be more pressured to teach to the test than their Turkish counterparts were, and the two countries have different teaching styles. The findings also showed that high-stakes examinations are: objective; encourage students to focus more on their studies and provide national homogeneity in education; they

encourage attention only to material covered in examinations and as a consequence many worthwhile educational objectives and experiences may not be addressed in their instructional practices (Abrams, Pedulla, & Madaus, 2003; Au, 2007; Koretz, McCaffrey, & Hamilton, 2001; Shepard, 2000). These examinations are often administered in a very limited time and they are also stressful. They negatively affect students' self-concept and self-esteem, and are often perceived to be unfair to students (Abrams et al., 2003; Leonard & Davey, 2001). The study focused on the impact of high-stakes examinations on teachers' instructional practices and students' learning, but this study focuses only on the effect of high-stakes assessment on mathematics teachers' instructional practices in Nigeria senior secondary schools.

Harlen and Crick (2003) reviewed some studies on the impact of high-stakes assessments and testing on students' motivation (intrinsic and extrinsic) for learning. One of the aims was to examine the evidence that high-stakes assessments raise standards and has a negative effect on motivation for learning mathematics. It was evident that intrinsic motivation correlated positively with conceptual understanding and high-level thinking skills of the students, while teachers motivated by high-stakes examinations are likely to have performance goals in their instructional and assessment practices.

Empirical studies have shown that students can develop a conceptual understanding of mathematics if mathematics teachers' instructional practices attend explicitly to concepts by connecting mathematical facts, procedures and ideas (Gamoran, 2001; Hiebert & Grouws, 2007). In the same vein, Brophy (1999) notes that if such instructional practices can be well structured in an orderly manner, the key mathematics ideas are connected through discourse in the classroom. This could include discussion of mathematical ideas underlying procedures, and asking questions about their differences and similarities in solution strategies. There is a need to consider the ways in which mathematical problems are approached as they build on each other. Attention should also be given to the relationships between mathematical ideas and reminding learners about the important point of the lesson and how these ideas fits within the order of lessons and ideas. Mathematics teaching for conceptual understanding also refers to mathematics teachers' instructional practices that consistently engage students in working with important

mathematical ideas and making sense of mathematics. The conceptual understanding of the students is tested in the high-stakes assessments.

Shepard and Dougherty (1991) studied the effects of high-stakes testing on instructional practices. The study was part of a larger research project concerned with the effect of testing on instructional practices and student learning. A total of 360 teachers in Grades 3, 5, and 6 in approximately 100 schools in two districts responded to questions that addressed test preparation/revision practices and the effects of testing on instructional practices. A limitation of the study was the overall response rate of 42%, suggesting that the respondents were not necessarily representative of all teachers.

The findings showed that teachers were under pressure from the district administration to improve test scores of the students. The simple reason is the importance attached to testing. Teachers placed greater emphasis on effective instructional practices. They felt that content that was not tested suffered because of the focus on the high-stakes testing. Testing further distorted teaching, because of the extensive time given to test preparation. While it was agreed that flagrant cheating was rare, practices that would clearly boost test scores, such as rephrasing questions, were considered to occur more frequently. Teachers were aware of extensive use of test results for significant educational decisions such as comparisons of performance between schools or districts. In open-ended questions teachers pointed to many benefits from high-stakes testing, but they felt that these were outweighed by the drawbacks.

Volger (2002) studied the impact of high-stakes state-mandated student performance assessments on teachers' instructional practices in Massachusetts. The purpose of the study was to determine whether the high-stakes state-mandated students' performance assessments influenced teachers' instructional practices. The focus of the study was on the changes that occurred in teachers' instructional practices and the factors that might have influenced such changes when the result of the assessment was publicly released. The researcher employed stratified random sampling of at least Grade 10 English, mathematics or science in academic public high schools within Massachusetts. Data were collected using 54 items questionnaire surveys. A total of 257 equivalents to 62% of the total sampled were completed and retrieved.

The findings showed that the instructional practices were influenced by high-stakes assessments in multiple ways. Teachers were found making positive changes in their instructional practices and their changes in instructional practices were mostly influenced by the Massachusetts comprehensive assessment system (MCAS) that enable students to graduate in high school. Therefore, the use of state-mandated students' performance assessment and the high-stakes attached to this type of assessment positively influenced the teachers' instructional practices. It also ensured that the schools improve students' performance. There was a significant increase in the use of open-ended questions, critical thinking questions, problem-solving activities, use of rubrics or scoring guides, writing assignments and use of inquiry. The use of multiple-choice questions, true/false, textbook-based assignments and the lecture method drastically reduced in teachers' instructional and assessment practices. The changes in teachers' instructional practices influenced educational best practice policy.

Some of the instructional and assessment practices reviewed are similar to those of Nigerian senior secondary schools. For example, the Massachusetts comprehensive assessment system studied by Volger (2002) is similar to WASSCE in WAEC high-stakes examinations where students are assessed using both objective (close-ended) and open-ended (free response) questions in mathematics. The objective questions usually test recall and application of knowledge while open-ended questions usually test students' critical thinking and problem-solving skills. These practices are also similar to other countries where students' solution strategies in high-stakes assessments suggest the use of open-ended questions (Agheti, 2011).

### **2.3 Examination-driven Instruction (EDI)**

Examination-driven instruction (EDI) is a preparatory practice for high-stakes examinations where the teachers teach only the content of previous examinations and anticipated questions that might come up in the next examination of a subject – like the senior secondary school mathematics (Julie, 2013a, 2013b; Popham, 1987, 2001). Similar terms used are: examination-driven teaching (EDT), measurement-driven instruction (MDI), assessment-driven instruction (ADI) and data-driven instruction (DDI). On the one hand, Davis and Martin (2008) conceptualize EDI as classroom mathematics

instructional practices that emphasize remediation, skill-based instruction over critical and conceptually oriented thinking, decreased use of rich curriculum materials, narrowed teacher flexibility in instructional design and decision making, and the threat of sanctions for not meeting standards of high-stakes examinations.

On the other hand, Popham (1987) asserts that MDI occurs when a high-stakes examination of educational achievement influences the instructional practices that prepares students for the examination. Due to the importance attached to students' performance in high-stakes examinations, Popham (2001a) argues that the consequences of high-stakes examinations for teachers and students does not matter most. He looks at the benefits that teachers, students, policymakers and other stakeholders in education will get from the high-stakes examinations. The proponent of EDI argued that when there is assessment, there must be teaching and the high-stakes assessments can motivate and guide teachers in the educational system to be more productive (Popham, 1987, 2003b, 2013; Shepard, 2000; Wayman, 2005). It is a way to improve the quality of education. It motivates learners in that the learning objectives are clear, and it can provide valuable solutions to teachers in making instructional decisions. These instructional, preparatory and revision practices are sometimes done in the Nigerian senior secondary schools as strategies for students to pass the high-stakes examinations. Yet such practices have their disadvantages.

The opponent of EDI assert that EDI fragments knowledge; it focuses on low content domains, which regularly become the only content learners are taught; it leads to a loss of mathematics content orderliness; it militates against flexibility of conceptual understandings; it narrows the curriculum by allocating a small amount of time to examination preparation; it makes teachers stressful; it deskills teachers and the psychometric paradigm which underlies most of the main high-stakes assessments is not always conducive to making good instructional decisions (Davis & Martin, 2008; Furner & Kumar, 2007; Gilmour, Christie, & Soudien, 2012; Hagan, 2005; Shepard, 2000; van den Heuvel-Panhuizen & Becker, 2003). In summary, in using EDI substantial teaching time is lost to high-stakes assessments rather than covering the curriculum to enhance students' understanding. Whatever the advantages and disadvantages are, the primary

focus of EDI is on high-stakes examinations; it allows an opportunity and means for transforming the teaching of senior secondary school mathematics (Julie, 2013a, 2013b; Burkhardt & Pollak, 2006). No matter what the limitations of EDI are, teaching will always be influenced by what is assessed and EDI uses high-stakes assessments and/or their content as their main points of departure in the senior secondary schools. Furthermore, Julie (2013a, 2013b) contends that it is an important characteristic of practices which involve assessments and that these assessments provide boundaries for and define the legitimate knowledge in mathematics.

However, one of the essential ways of planning for tests is that mathematics teachers should know how to design proper learning objectives. Learning objectives indicate the type of knowledge the teachers want students to acquire or be able to demonstrate at the end of the course, term, or class activity at different levels of cognitive ability (Bloom et al., 1956; Krathwohl, 2002). All the learning activities, including instructional methods and assessment strategies used, are driven by learning goals. For this reason, mathematics teachers should possess a good understanding of how to construct specific, measurable, attainable, realistic and learner-centred instructional goals (Airasian, 1994; Gronlund & Waugh, 2009; McMillan, 2005; Popham, 2008; Reynolds et al., 2009) as well as planning and revision strategies. Section 2.5 below will briefly explain some of the preparatory and revision practices for classroom teachers and high-stakes assessments that they can utilise in their instructional practices.

#### **2.4 Washback effect of high-stakes assessments**

Studies have shown that teachers are influenced by high-stakes assessments in their instructional and assessment practices, especially when they prepare their senior secondary school students for such assessments (Firestone, Camilli, Yurecko, Monfils, & Mayrowetz, 2000; Kellaghan & Greaney, 1992; Kellaghan, Greaney, & Murray, 2009; Popham, 1987; Smith, 1991). The influence manifests in the actions of mathematics teachers in response to the high-stakes assessments. One form of such manifestation is what is referred to as “washback” (or consequences). Cheng (1999) investigated the operation of the washback phenomenon on secondary school instruction in Hong Kong and found that the high-stakes examinations had a direct washback on teaching in the

examination classes as the teachers realigned their instructional practices with the requirements of the new structure of the examination. The activities they engaged in during lessons were directly related to what the students were expected to deal with in the high-stakes examinations, with little or no attention given to their conceptual understanding.

Similarly, Wright (2002) studied the impact of a high-stakes state-mandated test on teachers in an elementary school in California. Through observation and interviews with teachers in Grade 2, where the mandatory high-stakes testing starts, and in kindergarten for comparison. The finding was that the high-stakes testing was driving teachers' goals. In the case of Cheng (1999), the awarding body intended the new structure of the examination to have a washback effect on teaching that will produce positive effects by changing the competences of the students in a particular direction. The results of the examination determined, in part, progression to tertiary education. In Wright's (2002) study the state instituted the mandatory tests to compel teachers to improve the scores of the students on the high-stakes tests and attached monetary rewards to their performance. The findings showed that once there are serious consequences attached to the results either for teachers or their students, high-stakes assessments will influence teachers' classroom instructional and assessment practices. The researcher similarly investigated how high-stakes assessments influence mathematics teachers' instructional and assessment practices in Kaduna State senior secondary schools.

## **2.5 Revision practices for high-stakes assessments**

Revision practices are the strategies or approaches employed by mathematics teachers in preparing their students for both classroom and high-stakes assessments. Therefore, it is important to discuss some of the related terms which can be used by mathematics teachers in their instructional and assessment practices in the Nigerian senior secondary school classroom, especially during preparatory and revision practices for high-stakes assessments. Such terms include "distributed practice" (spaced practice, space presentation or repetition practice) (Smith & Rothkopf; 1984; Seabrook, Brown & Solity, 2005), "massed practice" (Julie et al., 2016) "productive practice" (Julie et al., 2016) "deliberate practice" (Ericsson, Krampe, & Tesch-Romer, 1993), "spiral testing" or "spiral

revision” (Wineland & Stevens, 1995), the “spacing effect” (Dempster, 1988), “shuffling of mathematics problems” (Rohrer & Taylor, 2007), “incremental approach” (Saxon, 1982; Klingele & Reed, 1984), “snappies” (Cramp & Nardi, 2000), These strategies reinforce previous learning and encourage retention of learned material (Wineland & Stevens, 1995). However, teachers should be aware of how these revision practices are influenced by high-stakes assessments. These terms for revision practice are not common in Nigerian senior secondary schools, but some teachers applied some of the methods without knowing, as shown in a few studies. Therefore, the researcher briefly explains those revision practices below.

### **Distributed practice**

Distributed practice is a revision strategy, when studying is spread across multiple sessions over time, or where practice is divided into a number of short sessions over a longer period of time (Julie et al., 2016). Students learn mathematics more easily when they study in many sessions spread out over an extended period of time, rather than studying it in mass in a short period of time. When preparing students for high-stakes examinations in mathematics, using instructional practices repeatedly over a long period of time will result in more effective learning than mass practice the night before examination.

Julie et al. (2016) and Smith and Rothkopf (1984) observe that multiple psychological functions are responsible for the beneficial effects of distributed practice and procedural, priming effects, and they recommend expanding retrieval support for distributed practice as a successful study strategy for the real world. The spacing effect and its underlying mechanisms have important applications to learning mathematics in Nigerian senior secondary schools (assessment formats of free-recall, multiple-choice, short answer, essay, performance). Mathematics teachers can enable students to retain their learning material over the long term through the choices they make when planning their classroom instructional practices.

### **Massed practice**

Massed practice refers to the situation in which students practice a task continuously without resting intervals within the practice session (Julie et al., 2016). In other words, it

is a concentrated solving of mathematics problems on a particular topic after the topic has been taught. This is engagement in what has been taught before conducting the assessment. Mathematics textbooks and past examinations question papers are normally structured to facilitate massed practice. According to Julie et al. (2016), Smith and Rothkopf (1984) and Seabrook et al. (2005), the disadvantage of this approach is that the students' retention of what is taught and learned is compromised.

In preparation for high-stakes assessments, massed practice is applied when students work through some relevant questions of a particular topic selected by the teachers from previous examinations on the topic (Julie, 2013a, 2013b; Julie et al., 2016; Popham, 2001). After this period of engagement with the questions related to the topic, the students are tested on the curriculum topic, with the questions selected from the previous examinations but which were not part of the practice set of previous examinations questions they were engaged with. This practice is sometimes similar to examination-driven instruction.

Massed practice is also called an over-learning technique and empirical studies have shown that the over-learning results in more subsequent performance in mathematics (Driskell & Willis, 1992), although some studies have found little or no benefit of overlearning (Rohrer & Taylor, 2007; Cepeda, Pashler, Vul, Wixted, & Rohrer, 2005). Most findings reveal that overlearning tends to improve subsequent test performance. These experiments perhaps explain the large support for overlearning as a learning technique (Foriska, 1993; Hall, 1989; Radvansky & Copeland, 2006). Yet it is important to be cautious about the utility of overlearning in the mathematics classroom, because the mathematics teachers' instructional practices can be stressful to the students. So many things learnt by students within a short period of time may confuse the students during high-stakes examinations.

### **Productive practice**

Productive practice is concerned about allowing the learners to develop general ways of working in school mathematics through deepening their thinking and ideas about mathematical problems whilst practising mathematics (Julie et al., 2016). Productive practice underpins effective instructional practices for senior secondary school

mathematics in that students are allowed to experience the learning of mathematics in the same way as expert mathematicians work. Practice is learning based on productive activity in social "serious situations", learning based on experience, of being able to achieve something important, both for oneself and one's environment (Julie et al., 2016). This may be similar to Schoenfeld's framework on teaching for conceptual understanding and Popham's framework for effective instructional and assessment practices.

Productive practice begins with activity, that is, learning is itself a product gained by the experience of productive activity and senior secondary school students acquire this with the help of their mathematics teachers (Julie et al., 2016). The students become active, to begin with, for the sake of the activity, to produce something, to improve, to achieve, to prevent, express, communicate, among other things. The students' engagement in these activities and understand the processes make learning productive in the mathematics classroom instructional practices. These productive activities can help senior secondary school mathematics students acquire knowledge and skills that will enable them to succeed in both classroom and high-stakes assessments.

### **Deliberate practice**

Mathematics teachers' deliberate practice as a revision in mathematics instructional practices are those activities that have been found most effective in improving students' performance in mathematics (Ericsson et al., 1993). In this practice the teachers instruct the students to engage in practice activities that maximize improvement in mathematics knowledge and skills. Ericsson et al. (1993) further explain that deliberate practice includes activities that have been specially designed to improve the current level of students' performance in mathematics. Given the students' instruction, the teacher designs practice tasks that the student can engage in between meetings with the teacher. Deliberate practice is a highly structured activity, the explicit goal of which is to improve students' performance in both classroom and high-stakes assessments, although, these revision practices are not common in Nigeria.

Ericsson et al. (1993) claim that deliberate practice requires effort and is not inherently enjoyable. When practised in Nigerian senior secondary schools by mathematics students, it may motivate them because deliberate practice may improve their

performance in the classroom assessments and in high-stakes assessments. Understanding of the long-term consequences of deliberate practice is important to both Nigerian senior secondary school mathematics teachers and their students in the instructional practices and performance in both classroom and high-stakes assessments.

### **Spiral revision**

This is the repeated practice of work previously covered in the classroom during instruction and through repeated practice learners get used to solution strategies for mathematical problem types that they will come across in the high-stakes assessments (Julie, 2013a). It is a way of developing familiarity with solution strategies of mathematical problems. The author further contends that the spiral revision strategy is deemed by mathematics teachers as a viable strategy and it is also seen as one of the variants of distributed practice. These “repeated practice” sessions of Cramp and Nardi (2000) were developed to be used in the mathematics class. These authors’ notion of spiral revision is the repeated practice of work previously covered by the teachers in class with the students. The goal of this practice is to improve the knowledge and skills of senior secondary school students in mathematics for conceptual understanding. Students will be able to employ mathematical concepts, facts, procedures and reasoning in high-stakes assessments and interpret, apply and assess mathematics learning outcomes as outlined in Nigeria mathematics curriculum (NERDC, 2007).

### **Cumulative practice**

These are instructional strategies or procedures of having students cumulatively practise previously mastered skills in mathematics (Sidman & Tailby, 1982; Van den Heuvel-Panhuizen & Becker, 2003). Cumulative practice begins by independently training two skills to criterion (particular standard limit to be achieved) and then practising them together, usually by mixing tasks for both skills within the same practice set and this procedure is continued until all the skills in a sequence or hierarchy have been acquired, with the mastered skills accumulating across the cumulative sets (Carnine, 1997; Carnine, Jones, & Dixon, 1994). Cumulative practice has been shown to produce greater efficiency in knowledge and skill acquisition (Gleason, Carnine, & Valia, 1991) and post-test achievement (Klingele & Reed, 1984; Saxon, 1982). Cumulative practice as a

revision practice is associated with improvements in knowledge and skill acquisition and high post-test achievement in high-stakes assessments.

Cumulative practice is concerned with the critical elements of cumulative procedures that result in excellent performance (Mckeown, Beck, Omanson, & Perfetti, 1983; Lipsey & Wilson, 1993; Wilson, Majsterek, & Simmons, 1996). Therefore, the positive effects may be a result of the process of review that is involved in cumulative practice procedures, where review is known as practice distributed over time. This type of revision practice may not be common in Nigerian senior secondary schools and one cannot determine how they influence high-stakes assessments.

### **Spacing effect**

This is the situation whereby outcomes of learning mathematics are greater when practices are spread out over time than in a single session (Julie, 2013a; Julie et al., 2016). It is believed that human beings easily remember or learn things in a list when they are studied a few times over a long period of time. For example, four practice problems might be assigned in a single session or divided evenly across two sessions with a one-week interval. The achievement interval equals the period of time between the last practice problem and the test. For example, if a skill is practised on Monday and Tuesday and tested on Friday, the achievement interval equals three days.

Assessment performance is generally improved after practice that is spaced rather than massed – a finding known as the spacing effect (Bjork, 1979, 1988, 1994; Carpenter & Lehrer, 1999). It is sufficient to simply note that spaced practice improves the performance in high-stakes assessments. To this effect, many researchers have suggested methods for students to space their studies (Bjork, 1988, 1979, 1994; Cepeda et al., 2005; Dempster, 1988). For instance, Smith and Rothkopf (1984) observed a spacing effect if several statistics lectures were spaced across four days rather than massed into one session. Cepeda et al. (2005), and Rohrer and Taylor (2006) recently observed improvement performance of spacing mathematics practice for learners who were assessed four weeks after their last practice problem. Hence, when Nigerian senior secondary mathematics teachers use space practice effectively in their revision practice

for WAEC high-stakes examinations, there may likely be improvement in their students' performance.

### **Shuffling of mathematics problem**

Practice problems in mathematics consist of problems corresponding to those in the previous lesson and those practice problems are systematically shuffled so that each practice set includes a variety of problems drawn from many previous lessons (Rohrer & Taylor, 2006). The practice problems are systematically organised so that they are both distributed and massed practice (Julie et al., 2016). Students either learn how to solve mathematics problem and subsequently practise them as mass practice in a single session or spaced across multiple sessions. This shows that mathematics teachers as they follow the prescribed textbooks in their mathematics instructional, preparatory and assessment practices unconsciously use the shuffling of mathematics problems.

### **Incremental approach**

Saxon (1982) sees the incremental approach as an instructional strategy for learning of mathematics sequentially. This is teaching a new mathematical concept daily and with constant revision of the old concepts. This type of learning of mathematics could be considered as learning from simple to complex ones. According to Saxon (1982), in an incremental approach to teaching and learning, the teacher splits the day's work evenly between practising the new material and reviewing old material. Teachers can encourage senior secondary school students who struggle with the problem of learning mathematics content for conceptual understanding to use increment approach as learning from simple to complex.

### **Snappies**

Cramp and Nardi (2000, p. 48) refer to "snappies" as "opportunities for revision, instant assessment" of learners' "understanding and linking with" previous knowledge. They are seen as an opportunity in preparatory, revision and assessment practices in mathematics teachers' instructional practices. This is a way of assisting the students of mathematics to identify areas of difficulty. The instructional and revision practices by teachers aim at providing remedies for learning problems or difficulties among senior secondary school

mathematics students. However, studies on these revision practices in mathematics are scarce. Therefore, more empirical studies should be conducted.

As mentioned earlier, most of these revision practices are found in developed countries, but reviewing them in this research may provide helpful knowledge to a developing country like Nigeria. Some of the practices may be used to mathematics teachers in their instructional, preparatory practices for time-restricted WAEC high-stakes examinations in Nigerian secondary schools. Therefore, it is important to choose proper revision approaches that will promote optimal student performance in WAEC high-stakes mathematics examinations.

## **2.6 Influence of high-stakes assessments on the senior secondary school mathematics curriculum**

Mathematics occupies a well-established position in the Nigerian senior secondary school curriculum because it is one of the core subject in the WAEC high-stakes examinations (FRN, 2004; NERDC, 1992, 2007). While there is wide acceptance of the importance of mathematics, there is also a lack of consensus regarding the content of the curriculum, how that content should be treated, and the overall purpose of the study of mathematics. The public expresses concern about the mathematical competence of students, which causes educators to examine the achievement of students more closely. Ball et al. (2008) define knowledge of the curriculum as the understanding of range of programmes that have been organized for instructional practices of subjects and topics (including mathematics) at a given level of education as well as all the relevant materials that are available for these programmes – for example, knowing the instructional materials that are available for teaching and learning of statistics in the senior secondary school such as the mathematical instruments for drawing graphs, the graph boards, calculators, amongst others.

Knowledge of the curriculum is concerned with selection and using good curriculum materials, and understanding the objectives and the important ideas of the curricula and the reference textbooks (Shuhua, Gerald Kulm, Zhonghe, 2004). It is well known that for senior secondary education, knowledge is formally declared in the intended curriculum and implemented in the taught curriculum (Julie, 2013a, 2013b). However, Bishop (1998)

and Bishop, Hart, Lerman and Nunes (1993) argue that high-stakes assessments have become significant components of the intended mathematics curriculum and currently determine the implemented curriculum. The intended and interpreted curricula provide boundaries of content to be dealt with, but the implemented curriculum (Ben-Yunusa, 2008; Ndlovu & Mji, 2012) is heavily driven by the examined curriculum. In the interaction of curricular variations (the intended, interpreted, implemented and examined curriculum), the implemented curriculum that becomes the examined curriculum is the one that is eventually constitutive of the legitimate knowledge that is taught for the sake of the high-stakes examinations.

Davis (2009) thinks that the teachers' success in implementing curriculum materials in the classroom instructional practices depends on their beliefs about the role of curriculum materials and their instructional, preparatory practices for high-stakes assessments. The Nigerian senior secondary schools use the mathematics curriculum is aligned with the WAEC syllabus. Teachers also used these materials as a guide in their instructional practices and in constructing tests items or examinations questions. In test construction, a table of specification is use bearing in mind the mathematics content taught and the cognitive levels to be tested. Mathematics teachers and WAEC high-stakes examinations in their test constructions use these teaching and learning materials. The question is how justifiably are the mathematics teachers and WAEC high-stakes examination using them?

The current South African Curriculum Assessment and Policy Statement (CAPS) for Mathematics in Grades 10 to 12 (equivalent to SSS1 to SSS3 in Nigeria) gives the weighting of knowledge hierarchies known as percentage distribution of knowledge problem types for the mathematics examination spread into 20% for knowledge, 35% for routine procedures, 30% complex procedures and 15% problem solving (Department of Basic Education (DBE), 2011).

In Nigeria the content of the general mathematics curriculum (NERDC, 2007, 2014) is grouped into six main sections (number and numeration, algebraic processes, mensuration, plane geometry, trigonometry, and statistics), but recently reviewed and reduced to five content areas similar to those of the National Council of Teachers of Mathematics (NCTM, 2000) with each section occurring every year of the three senior

secondary school programmes as emphasized by the Nigerian Educational Research Development Council (NERDC, 2007). The cognitive levels are differentiated into knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, Engelhart, Frust, Hill & Krathwoml, 1956).

As mentioned earlier (see section 1.4.1), in recent years the Nigerian mathematics curriculum from primary to the tertiary institution in Nigeria has witnessed several changes in terms of contents, performance objectives, activities, methods and materials, in order to, amongst other things, make it more relevant and adaptable to changes occurring every now and then in society (NERDC, 2007). One such recent change is the shift away from the 6-3-3-4 system of education (i.e. 6 years of primary school, 3 years of junior secondary school, and 3 years of senior secondary school and 4 years of university education) to 9-3-4. This change led to the development of 9-year basic and senior secondary education mathematics curricular that was published in 2007 by NERDC (2007). However, there have been no corresponding changes in the general objectives of the secondary school mathematics curriculum (Odili, 2006). The mathematics curriculum in Nigeria has clearly spelled out the contents to be learnt at each level of education. For successful implementation, mathematics teachers should understand the contents of the curriculum and plan their mathematics instructional practices in the senior secondary school classroom for optimal performance of students in high-stakes assessments.

Teaching Today (2005b), an American policy document, outlines the important characteristics of an effective standards-based mathematics instruction as: lessons designed to cater for some standards-based concepts or skills; student-centred learning activities; inquiry and problem-solving focused lessons; critical thinking, knowledge and application skills; enough time, space and sufficient learning materials; varied, continuous assessment, designed to evaluate both students' progress and teachers' effectiveness. These characteristics for effective standards-based mathematics instruction (NERDC, 1992, 2007) are similar to what is expected of the selected Kaduna State senior secondary school mathematics classrooms.

Unfortunately, Joseph, Green, Mikel, and Windschitl (2011) note that some teachers often say that there is no curriculum any more, that the policy of instruction is for teachers to

prepare the students to write the high-stakes examinations. This implies that some mathematics teachers are going to ignore the mathematics curriculum and just get revision textbooks, examination question papers and other materials relevant for preparing students for the high-stakes examinations. These teachers' beliefs are similar to what Popham (2001b) calls 'teaching to the test' and not teaching to the curriculum, hence robbing students of Schoenfeld's (2016, 2017a) perspective on teaching for the robust understanding (TRU) of mathematics. Heyer and Pifel (2007) suggest that the curriculum should be seen as a process of creating a rich and meaningful programme of study that integrates their knowledge of pedagogy, scholarship in the academic discipline, educational research, learners' and families' needs and interests. Therefore, the mathematics curriculum should not be seen as a summarised reference document for the sole purpose of passing high-stakes examinations.

Joseph et al. (2011) recommend that schooling has come to serve and emulate industry, which has led to contraction of the curriculum to become a guiding instrument used in preparing students for the high-stakes examinations and not the development of well-grounded individuals. The authors' further lament that such limited views of education have had devastating consequences on students' educational experiences, creating inequality of school resources and opportunities, and devaluing teachers as professionals. The current trend is how best to improve the students' performance in high-stakes examinations. This practice is observed in mathematics teachers' instructional practices. Practices such as memorization, drilling, coaching, test preparation and other types of learning activities are designed simply to help students to perform well in high-stakes examinations.

In most of the review, the mathematics curriculum is seen as an instrument aligned with examination questions for preparing students for high-stakes mathematics examinations not a better taught mathematics (Teese, 2000). Additionally, the quality of instructional practices is viewed extensively in terms of the effectiveness of students' preparation for high-stakes assessments. Bishop (1998) regards these preparatory practices as leading to the technique-oriented curriculum demanded by the examinations.

Since the WAEC syllabus is an offshoot of the national curriculum, their reviews and reforms always go *pari passu* (i.e. go hand in hand) (see section 1.13.1 and 1.13.2). The current curriculum in use by Nigerian senior secondary schools is the one reviewed by NERDC (2014) and the WAEC syllabus also currently in use is that one reviewed by WAEC (2015). This study made a comparative analysis of these documents (mathematics curriculum and WAEC syllabus) to verify the correlation of contents.

## **2.7 Use of instructional materials in senior secondary school mathematics**

The use of teaching aids in mathematics instructional practices cannot be overemphasized. This is because mathematics is sometimes seen as a difficult subject in Nigerian senior secondary schools and extra effort is required to bring students to understanding concepts, principles and applications (Sani, 2015). More specifically, many principles and concepts in mathematics are not easily explained by means of common sense deduction. This obviously increased the level of difficulty students encounter in making sense of mathematics generally. Examples of these concepts are symmetry, place value, addition, subtraction, number system, geometry, probability as well as longitude and latitude to mention a few. The abstractness of these concepts requires recourse to concrete instructional materials.

Sani (2015) furthermore laments that the major problem militating against improvisation in Nigeria is lack of adequate professional training of teachers. Improvisation demands a sense of adventure, creativity, curiosity and perseverance on the part of the teacher. Such skills and competencies are only acquired/gained through well-planned training programmes on improvisation. Another factor that could hinder improvisation is lack of funds. Whatever the hindrance, it is more beneficial to improvise even where the real apparatus is not available than to present mathematics lessons without instructional materials. When senior secondary school mathematics is taught in a dull, confusing and trivial way, it limits meaningful learning and makes limited demands on students' intelligence, capabilities and talents (Sani, 2015). The Nigerian senior secondary school students nowadays pay attention mostly to preparation for high-stakes assessments other than learning mathematics for the sake of conceptual understanding. Therefore, in their mathematics instructional practices the senior secondary school teachers should be

encouraged to use concrete instructional materials for effective teaching and meaningful learning. Such mode of teaching mathematics tends to arouse the curiosity and interest of the students and lays a foundation for creative, imaginative and investigative minds to strive for success in high-stakes assessments.

## 2.8 Pillars of mathematics teachers' decision making in their instructional practices

The theory of teacher decision making as propounded by Schoenfeld (2011) is centred on three concepts: teacher resources (teachers' knowledge), goals and orientations (teachers' views and beliefs). The theory provides a lens through which mathematics teachers' instructional practices can be observed in Kaduna State senior secondary schools. Schoenfeld's (2011) theory provides pillars on which to structure an understanding of teachers' decision making in their instructional practices. The six steps used by (Schoenfeld (2011, p. 3) are given in Figure 2.1.

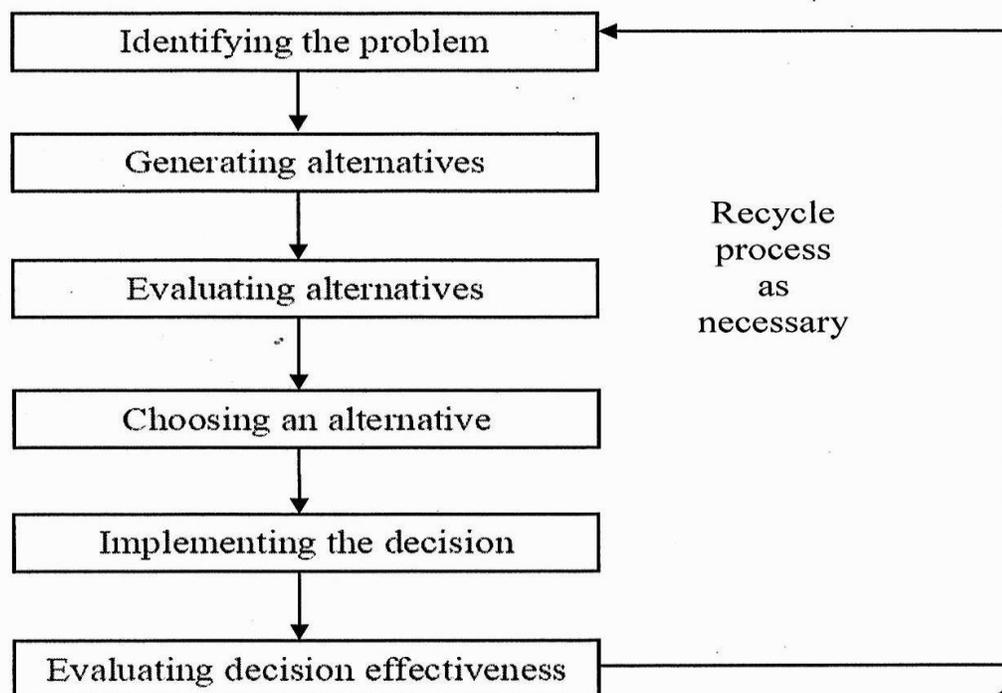


Figure 2. 1 The decision-making process Schoenfeld (2011, p. 3).

In a decision-making process, as indicated in Figure 2.1, when a problem has been identified, alternative solutions to the problem need to be generated. These alternative

solutions are carefully evaluated, and the best alternative is chosen for implementation. To determine the immediate and continued effectiveness of the solution, the implemented alternative is evaluated over time. If difficulties arise at any stage in the process, recycling may be effected until the problem is permanently solved. Therefore, teacher' knowledge, goals and beliefs as pillars of decision making are paramount to mathematics teachers in meeting their obligations and duties in the senior secondary school classroom and the entire school system.

## **2.9 Mathematics teachers' self-efficacy as a construct in instructional practices**

Self-efficacy has its roots in the social cognitive theory formulated by Bandura (1977) and it refers to the degree to which an individual believes and has confidence that he/she can perform specific tasks. So, self-efficacy is the belief one has the capacity to successfully undertake or execute a programme of action. Self-efficacy is used in this study as a construct to measure instructional practices. The individuals with higher self-efficacy are supposed to have higher aspirations, strong commitments to their goals, and recover more quickly from setbacks than those with low self-efficacy (Sharma, Loreman, & Forlin, 2012). It also affects an individual experience, vicarious experience, verbal persuasion and physiological state of mind. Corroborating the previous definitions (Pajares, 2002), conceptualizes self-efficacy as the confidence that people have in their ability to do the things they have an interest in.

Teachers' self-efficacy is a set of beliefs teachers hold about their own abilities and competences to teach and influence student behaviour and academic achievement regardless of outside influences or obstacles (Bandura, 1993; Bosan, 2018; Steele, 2010). Beliefs in teacher's self-efficacy can cut across academic subjects; therefore, self-efficacy for mathematics teachers is paramount for effective mathematics classroom instructional practices for success in high-stakes examinations. Self-efficacy in instructional practices influence the mathematics teacher's goal-setting performance and persistence of effort in the face of difficulties (Bosan, 2018). Nigerian mathematics teachers at the senior secondary school are doing their best in discharging their duties in the school system, but there are areas where they need intrinsic motivation to be able to meet the current international standards and the demands on the performance of students

in WAEC high-stakes examinations (Ogundele et al., 2014). One of these areas is teacher self-efficacy. Ogundele *et al* (2014) further emphasize that teacher self-efficacy is an educational construct and a key factor in teachers' effectiveness that neither the government nor researchers in Nigeria are giving sufficient attention. There is a need to motivate mathematics teachers to develop the self-efficacy that will give them confidence to be effective in their instructional practices to guarantee students' success in WAEC high-stakes examinations.

Furthermore, self-efficacy has permeated diverse areas of human endeavour and particularly in the educational domain of mathematics teachers' instructional practices (Pajares, 2002; Lent, Brown, & Larkin, 1986). Teachers with high levels of self-efficacy have been shown to be more resilient in their instructional practices and likely to persist in difficult times to help students reach their academic goals in mathematics (Pendergast, Garvis & Keogh, 2011). Therefore, teacher self-efficacy as an educational construct can possibly motivate mathematics teachers to commit themselves to effective instructional practices and equally assist senior secondary school students' performance in WAEC high-stakes examinations.

Additionally, it is a known fact that students come from different home backgrounds and that some are brilliant while others are not (individual differences). Some can easily take correction while some cannot; and some are already even spoiled at home and they are in school for the teachers to teach them mathematics. But any mathematics teacher with high self-efficacy will not regard any student as unteachable. Teachers with strong self-efficacy beliefs will persist with low-achieving students and use better instructional strategies that allow such students to learn more effectively. Conversely, teachers with low self-efficacy spend more time on non-academic tasks and use fewer effective instructional strategies, which hinders student learning (Sharma et al., 2012). For example, mathematics teachers with low self-efficacy may spend most of their time during the lesson telling stories to the students or asking questions that are not related to the lesson of the day.

Furthermore, teachers' self-efficacy has been consistently associated with students' academic achievement (Holden, Groulx, Bloom, & Weinburgh, 2011; Westbury, Hansén,

Kansanen, & Björkvist, 2005). When teachers have high self-efficacy, they are most likely to work harder to learn a new task as they will be more confident in their abilities than teachers with low self-efficacy (Bandura, 1993). For example, Bosan (2018) undertook an analytical study of personality factors affecting Kaduna State secondary school students' achievement in mathematics and one of the factors was self-efficacy of the students. The study showed that mathematics self-efficacy has direct causal link with learning outcomes in mathematics with reference to mathematics WASSCE in WAEC high-stakes assessments. Therefore, senior secondary school students with high self-efficacy have confidence in themselves and can perform very well in high-stakes examinations, while those with low self-efficacy may perform very lowly in mathematics.

### **2.10 Mathematics teacher knowledge as a variable in mathematics instructional and assessment practices**

Mathematics teacher resources or mathematics teacher knowledge is important to mathematics instructional practices, because they form the foundation for teacher effectiveness in the classroom (Blum & Krauss, 2006; Shulman, 1986, 1987). Teacher knowledge is the teacher's awareness or understanding of facts gained through association or experience, books, media, academic institutions and other sources. Schoenfeld, (2011, p. 25) focuses more on "knowledge" when discussing "teacher resources". Schoenfeld defines knowledge as information that the teacher has for his/her instructional practices and in pursuance of educational goals in mathematics. Schoenfeld (2011) proposes five components of knowledge: (1) knowledge matters in problem solving; (2) knowledge as being associative, (3) knowledge as memory is associative – things that belong together are remembered together; (4) knowledge gets activated and accessed in ways that entail related actions and associations; (5) knowledge structures are connected, generative and regenerative. This shows that knowledge is neither static nor absolute. Schoenfeld (2011) considers mathematics teacher knowledge to be a very precious intellectual resource. This mathematics teacher knowledge influences goal-setting performance, persistence of effort and effectiveness of instructional and assessment practices in the school system.

Petersen (2005) also argues that instructional practices are based on decisions that take into account content, students and professional knowledge. Mathematics teacher

knowledge is a complex and multifaceted domain. It includes knowledge of instructional strategies gained through formal pre-service education and/or in-service teacher development programmes. Such knowledge is also known as knowledge gained through professional experience. Blum and Krauss (2006) state that there are many questions about the content of teacher knowledge, its structure influences instructional practices. Therefore, it is vital to develop teacher knowledge to make a positive change in the mathematics teachers' instructional and assessment practices for optimal performance of senior secondary school students in the classroom and in the high-stakes assessments.

### **2.10.1 Dimensions of teacher knowledge for effective mathematics instructional and assessment practices**

To develop teacher knowledge for positive change in the mathematics teachers' instructional practices, the following need to be taken into account: the knowledge domains that are important for effective mathematics instructional practices; the knowledge of more proficient teachers; and facets of teacher knowledge due to the complexities and variabilities of the nature of expert knowledge. Shulman (1986) reframes the study of teacher knowledge in ways that attend to the role of content in instructional practices. Shulman further divides knowledge into three categories: knowledge base for the beginning teacher, curriculum knowledge and pedagogical content knowledge. These categories are related to teacher content knowledge. The author later specified seven categories of knowledge base for teaching: knowledge of content; knowledge of curriculum; pedagogical content knowledge; knowledge of pedagogy; knowledge of learners and learning; knowledge of contexts of schooling; and knowledge of educational philosophies, goals and objectives.

The seven categories of knowledge defined by Shulman were reorganized by Grossman (1990) into four main categories: subject matter knowledge (SMK), general pedagogical knowledge (GPK), pedagogical content knowledge (PCK), and knowledge of context (KC). The categorization is shown in Figure 2.2.

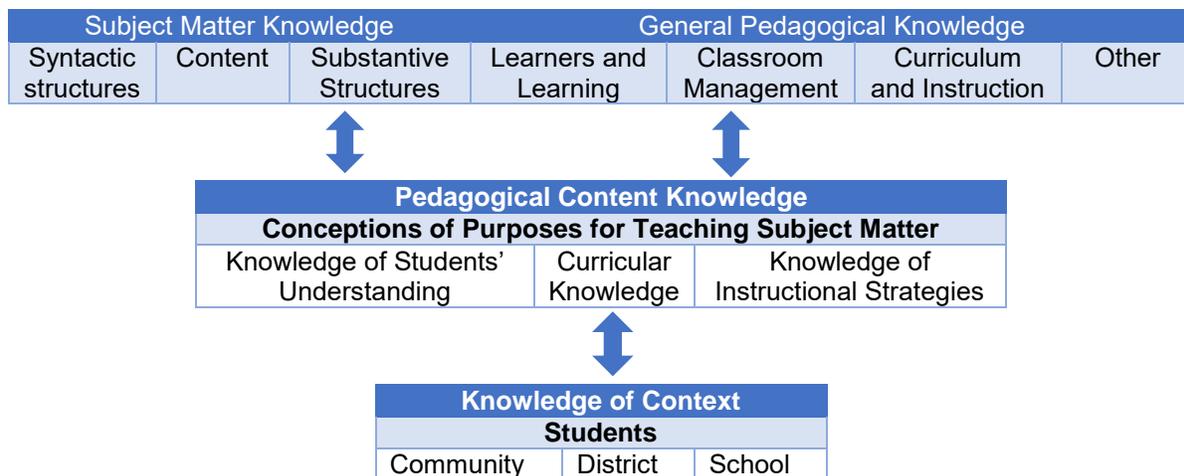


Figure 2. 2: Model of teacher knowledge (Adapted from Grossman, 1990, p. 5)

From Figure 2.2, Grossman's SMK was composed of the same components as that defined by Shulman (1986): knowledge of content, syntactic structure of a discipline, and substantive structures. Grossman placed Shulman's third component of curriculum knowledge into the PCK category (labelled as curricular knowledge). The general content knowledge is also composed of knowledge of learners and learning, knowledge of classroom management, knowledge of curriculum and instruction among others. In the Nigerian context, the PCK was composed of mathematics curricula knowledge, knowledge of instructional strategies and knowledge of students' understanding, which can assist the teachers in their mathematics instructional, preparatory and assessment practices in the senior secondary schools.

Ball et al. (2008) analyse the literature on mathematical knowledge for teaching (MKfT) at that time and identified the elements that seemed essential for the mathematics teachers. They studied the mathematics instructional practices rather than teachers, in order to analyse the mathematical demands of teaching. Several reports have already been published regarding discernible categories in the framework (Ball et al., 2008; Hill & Ball, 2009). Ball and her colleagues created the term "mathematical knowledge for teaching" (MKfT) to refer to a special kind of knowledge required only for mathematics instructional practices. Figure 2.3 below graphically presents the differences and similarities SMK and PCK

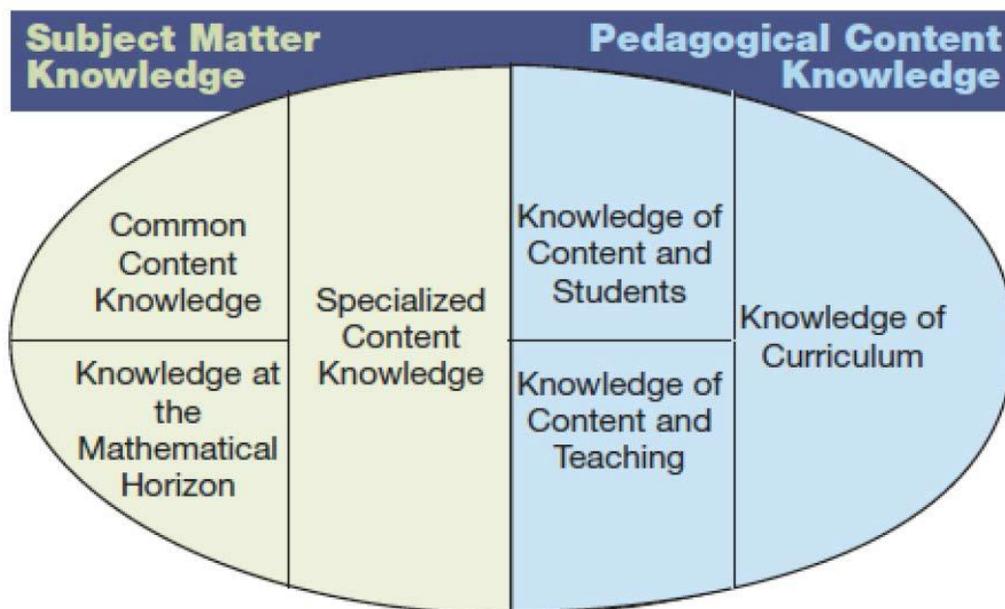


Figure 2.3: Model of teachers' mathematical knowledge for teaching (adapted from Ball et al. 2008, p. 403)

In Figure 2.3 Ball et al. (2008) categorize their model of teachers' mathematical knowledge for teaching (MKfT) into two main domains: SMK and PCK. According to Ball et al. (2008), SMK consists of three sub-domains: common content knowledge (CCK), specialized content knowledge (SCK), and knowledge at the mathematical horizon (or horizon content knowledge). The third component of teachers' SMK, knowledge at the mathematical horizon, is described as a provisional category recognizing connections among topics throughout the curriculum. The PCK is also composed of three sub-domains: knowledge of content and students (KCS) (knowledge of how students think and learn the content of mathematics), knowledge of content and teaching (KCT) (knowledge of content of mathematics and how to teach it), and knowledge of content and curriculum (KCC) (knowledge of selection of topics, achievement goals and the textbooks to use). Similarly, KCS and KCT were identified as two different constructs of pedagogical content knowledge.

Hill et al. (2008) investigated the role that teachers' MKfT plays in their instructional practices. The results showed that there is a substantial link between MKfT and high quality of mathematical instruction practices. In the findings teachers with high MKfT provided better instruction to their students than those with lower MKfT. Teachers with a

high quality of instructional practices exhibited the following qualities; they: (1) avoid mathematical errors and missteps; (2) deploy their mathematical knowledge to support explanations and reasoning, and analyse and make use of learner mathematical ideas better than would otherwise have been possible; create rich mathematical environments for their learners; (3) are critical of their mandated curriculum, and like to invest considerable time in identifying and synthesizing activities from supplemental resources; (4) provide high-quality mathematical lessons; (5) provide high-skill responses to students; and (6) choose examples wisely to ensure equitable opportunities for learning (Schoenfeld, 2017a). Therefore, from Hill and his colleagues' findings, it can be deduced that teachers' MKfT influences instructional practices in the senior secondary school and ultimately student performance in the classroom and the high-stakes assessments.

### **2.10.2 The state of teachers' mathematical PCK in instructional and assessment practices**

Pedagogical content knowledge (PCK) is a very important educational construct as well as a characteristic of teacher knowledge of how subject matter should be taught (Koh, Chai, & Tsai, 2010; Gierdien, 2008). PCK as defined and described by Shulman (1987) allows researchers to focus on an elusive form of instructional practice and teacher knowledge. PCK is a "particular form of content knowledge that embodies the aspects of content most germane to its teachability" (Shulman, 1986, p. 9). Shulman argues that the mathematics teacher must have at hand a range of techniques of alternative forms of representation, some of which derive from research, while others originate in the wisdom of instructional practices. Therefore, mathematics PCK can be seen as the mathematics teacher's knowledge of the nature of the mathematics to be taught, of how the students learn the mathematics, of how best to teach the mathematics, of the materials that are suitable for teaching the mathematics, and of how the mathematics fits into the curricula.

Hill et al. (2008) further classify PCK into three domains: knowledge of content and student (KCS); knowledge of content and teaching (KCT); and knowledge of the curriculum (KC). Manizade and Mason (2011, p. 187) constructed four components of PCK from the literature: (1) knowledge of connections among big mathematical ideas; (2) knowledge of learning theories describing students' developmental capabilities; (3)

knowledge of common student misconceptions and subject-specific difficulties; and (4) knowledge of useful representations and proper instructional techniques for the teaching of the content. Therefore, it is important to note that knowledge and experience of pedagogical practices influence mathematics teachers' instructional practices. This categorization of PCK is concerned with the mathematics teacher's knowledge of mathematics, knowledge about content of mathematics curriculum, the principles and practice of mathematics instructional practices, as well as the ability of the Nigerian senior secondary school students taught mathematics to perform excellently in any high-stakes assessment.

Furthermore, the ineffective teachers' instructional and preparatory practices for high-stakes mathematics examinations evident from poor PCK and resulting in poor performance in Nigeria senior secondary school's students in mathematics (Ogundele et al., 2014). For example, the first accusing finger always points at teachers being responsible for students' poor performance in WAEC high-stakes examinations in Nigerian senior secondary schools. Odia and Omofonmwan (2007) emphasize that teacher training colleges in Nigeria are responsible for producing teachers that have inadequate knowledge of subject matter, and poor pedagogical knowledge and skills. A teacher who is inefficient in terms of knowledge of the subject matter can only fumble in his/her instructional practices. There are also mathematics teachers who have knowledge of the subject matter but cannot impart the knowledge to the students; they have the content knowledge but lack pedagogical knowledge.

In an earlier study Kanyongo, Schreiber and Brown (2007) used hierarchical linear modelling to look at some of the school and home-environment factors that influence mathematics achievement in three Southern African countries in Botswana, Namibia and Lesotho. In their study they found that teachers' content knowledge of mathematics was one of the factors influencing mathematics achievement. As a follow-up to that study, part of the current study focuses on those instructional practices that are related to high-stakes assessments in mathematics. Teacher content knowledge of mathematics has become a popular topic because of the legislation concerning highly qualified teachers in the United States and other developed countries. Although teacher content knowledge influences

instructional practices, it is neither instructional practice nor is it related to the effect of high-stakes assessments. In Nigeria the literature on the effect of high-stakes assessments on teachers' instructional practices is scarce.

Several other studies found that teachers' content knowledge is important in three main ways: it influences how teachers engage students with the subject matter, it influences how teachers evaluate and use instructional materials, and it is related to what students learn in the classroom. Anders (1995) conducted a study in which she used teachers' content knowledge as a classroom script for mathematics instruction among second and third-grade teachers. The findings showed that teachers' content knowledge influences their instructional practices. Hence, the teachers' instructional practices can also be influenced by high-stakes assessments in the school system.

### **2.10 Mathematics teachers' beliefs on effective mathematics instructional practices**

Factors that influence mathematics teachers' instructional practices are complex. Therefore, to improve mathematics instructional practices in the senior secondary school in Nigeria, one must look at teaching from different angles. One of these factors is teacher's beliefs. The question is: How do teachers' beliefs about high-stakes assessments affect their instructional and assessment practices in Nigerian senior secondary schools? Beliefs are "mental constructions based on evaluation and judgment that are used to interpret experiences and guide behaviour" (Pedersen & Liu, 2003, p. 74). In the same vein, Barcelos (2003) sees beliefs as a form of thinking that cuts across all matters that individuals do not have sufficient knowledge about, but have enough trust in to work on them. Beliefs are seen as a variable that influenced mathematics teachers' instructional and assessment practices. Therefore, teachers' beliefs are one of the most significant constructs in the psychological composition of the teacher (Mansour, 2009; Stiggins & Bridgeford, 1985). They are also a holistic conception of many dimensions related to curricula and the teaching profession (Ghaith, 2003). These variables influence the teachers' instructional and assessment practices.

Furthermore, Phillip (2007) refers to mathematics beliefs as personal judgments that are made about mathematics, experiences in mathematics, beliefs about the nature of

mathematics, learning mathematics, and teaching mathematics. By implication, individual teachers hold a range of beliefs that influence their instructional practices. A careful consideration of the above definitions shows that beliefs are considered to be very influential in determining how individual mathematics teachers frame their mathematical problems and tasks in the mathematics classroom in Nigerian senior secondary schools.

In this study the researcher addresses the question: What is the effect of high-stakes examinations on the Kaduna State mathematics teachers' beliefs about what it means to teach mathematics effectively? The answer to this question will explain how mathematics teachers' beliefs influence classroom instructional practices and students' performance in high-stakes assessments. Mathematics teacher beliefs are classified into three groups: beliefs about what mathematics entails; beliefs about mathematics instructional practices; and beliefs about meaningful learning of mathematics (Grootenboer, 2008). The beliefs reflect how teachers conceptualize their choice of classroom learning activities, and the instructional strategies that they use. Beliefs are considered central to the way in which teachers conceptualize and actualize their mathematics classroom instruction practices, and also central to any efforts that are made towards improving their students' learning (Cross, 2009; Fosnot & Dolk, 2005; Handal & Herrington, 2003; Rösken et al., 2001). The mathematics teachers' beliefs could reflect their choice of classroom instructional materials and activities, the instructional strategies that they use, and the preparatory and revision practices for high-stakes assessments.

However, mathematics teachers hold different views and beliefs about what it means to teach mathematics effectively. On the one hand, some teachers hold the belief that the teacher is the provider of knowledge (i.e. traditional teachers' view); on the other hand, others hold the belief that the teacher is the facilitator of learning (i.e. non-traditional teachers' view) (Raymond, 1997). Teachers believe that they can make a difference in learners' lives and believe that they teach in ways that demonstrate this belief. The two different views on teacher beliefs are outlined in Table 2.2.

Table 2. 2: Teachers' beliefs about effective teaching of mathematics (Raymond, 1997, p. 560)

Traditional teacher's belief about the teaching of mathematics	Non-traditional teacher's beliefs about the teaching of mathematics
<p><b>The teacher's role is to:</b></p> <ul style="list-style-type: none"> <li>• Lecture and dispense mathematical knowledge; and</li> <li>• Assign individual set of work.</li> </ul> <p><b>The teacher:</b></p> <ul style="list-style-type: none"> <li>• Seeks the 'right answers', and is not concerned with explanations;</li> <li>• Approaches mathematical topics individually, one day at a time;</li> <li>• Emphasizes the mastery and memorization of skills and facts;</li> <li>• Instructs solely from the textbook;</li> <li>• Assesses learners solely through standard quizzes and examinations;</li> <li>• primarily values right answers over process;</li> <li>• Emphasizes memorization over understanding;</li> <li>• Primarily (but not exclusively) teaches from the textbook;</li> <li>• Includes a limited number of opportunities for problem-solving; and</li> <li>• Plans and implements lessons explicitly, without deviation. Lesson activities follow the same pattern daily.</li> </ul>	<p><b>The role of the teacher is to:</b></p> <ul style="list-style-type: none"> <li>• Primarily engage learners in the undertaking of problem-solving tasks;</li> <li>• Primarily present an environment in which learners are active, although they may occasionally play a more passive role;</li> <li>• Primarily evaluate learners using means beyond the standard examinations;</li> <li>• Encourage mostly learner-directed discourse;</li> <li>• Select tasks based on learners' interests and experiences;</li> <li>• Select tasks that stimulate learners to make connections;</li> <li>• Select tasks that promote communication about mathematics;</li> <li>• Create an environment that reflects respect for the learner's ideas, and structures the amount of time that is necessary to grapple with ideas and problems;</li> <li>• Pose questions that engage and challenge the learners' thinking;</li> <li>• Have the learners clarify and justify their ideas both orally and in writing;</li> <li>• Have the learners work cooperatively, encouraging communication among them; and</li> <li>• Observe and listen to learners when assessing learning.</li> </ul>

Table 2.2 indicates traditional teachers' belief about mathematics instructional practices focused on completion of instructional tasks that aimed at achieving correct answers by depending on the memorization of facts, rules, formulas, definitions, the use of algorithms, and the reproduction of familiar material (Henning, McKeny, Foley, & Balong, 2012). The non-traditional teachers' belief about mathematics instructional practices focused on student-centred learning and meaningful learning for knowledge and skills. Therefore, mathematics instructional practices that are student-centred and lead to acquiring knowledge and skills promote meaningful learning for the senior secondary school students' success in classroom assessment and the high-stakes assessments.

Van der Sandt (2007, p. 345) generates a research framework categorizing teachers' beliefs and effective teaching of mathematics; some of the dimensions are:

(a) teacher beliefs about the nature of mathematics: (i) problem-solving approach – teaching is driven by dynamic problems; (ii) instrumentalist view – teaching presents mathematics as an unrelated collection of facts, rules etc.; and (iii) Platonist view – teaching presents mathematics as a system of interconnecting structures that should be discovered;

(b) Teacher beliefs about mathematics instructional practices: (i) learner focused – focused on the learner's construction of knowledge; (ii) content focused (emphasis on conceptual understanding) – teaching is driven by the content itself; (iii) content focused (emphasis on performance) – teaching is driven by making sure learners master procedures and algorithms; (iv) classroom focused – a well-structured and well-organized classroom is the focus.

Van der Sandt (2007), therefore, links teacher beliefs to the type of activities performed in a mathematics classroom. The dimensions are related to Schoenfeld (2016, 2017a) framework of teaching for robust understanding (TRU).

Pajares (1992a) reminded us that all teachers hold beliefs about their students, work and mathematics as a core subject in most curricula. Pajares (1992a, p. 316) also maintains that beliefs are of an enduring nature, unless “deliberately challenged”. The mathematics teachers' instructional practices should therefore not only focus on teacher beliefs but make teachers “aware of their own beliefs” (Van der Sandt, 2007, p. 349). It is through this knowledge, reflection and challenge that changes in teachers' beliefs may occur positively for optimal instructional practices that may lead to improved achievement in the classroom and in high-stakes assessments.

Changing teacher beliefs is difficult (Pajares, 1992a). The author maintains that the earlier a belief is incorporated into a belief structure, the stronger it is. This may explain why professional training in mathematics instruction for a longer duration is more successful. It also explains that a teacher's understanding of the work of teaching is formed through many years of observing teaching as student-centred. At the end of the day, as

summarized by Hargreaves (1994), what teachers think, what teachers believe, and what teachers do at the level of the classroom instruction is ultimately shape by high-stakes assessments. It is true that mathematics teachers' thinking, beliefs and instructional practices in the classroom affect the students' performance at the high-stakes assessments.

Several researchers have shown that teachers' beliefs influenced their classroom instructional and assessment practices (Fang, 1996; Handal & Herrington, 2003; Pajares, 1992b; Tsui, 2003). How do high-stakes assessments shape teacher's beliefs and instructional practices? Pajares (1992b) summarizes the results of research on teachers' beliefs by indicating that there is a strong relationship between the pedagogical beliefs of teachers, their preparation for teaching, teaching decisions and classroom instructional practices. Pajares adds that the pedagogical beliefs of teachers before service play a central role in the explanation of knowledge and teaching behaviour when joining the teaching profession. In his opinion, these beliefs are the strongest factors through which one can predict effective teaching behaviour. It is obvious that mathematics teachers' interest in teaching as a profession during pre-service training and their beliefs about what it means to teach mathematics predict their potential instructional practices. Ernest (1989) also contends that teachers' beliefs have a strong effect on the mathematics instructional practices by converting those beliefs into a practical reality in the classroom. On the one hand, individuals see mathematics teacher's beliefs as a rich store of knowledge that may positively affect instructional preparations and thinking in the school system. On the other hand, high-stakes assessments may shape teachers' beliefs and their instructional practices.

There is an increasing interest in studying the relationship between teachers' beliefs, their classroom instructional practices and high-takes assessments. Although some studies (Nespor, 1987; Van Zoest, Jones & Thornton, 1994) have shown that the teachers' classroom instructional practices were inconsistent with their beliefs, some researchers found that the teachers' beliefs played significant role in the classroom instructional practices. It was also found that teachers' beliefs influenced their mathematics instructional abilities on how they plan and present their lessons as well as their

assessment practices (Broby, 1987; Daniel & King, 1998; Farrow, 1999) In the same way, high-stakes assessments may influence mathematics teachers' instructional practices. This can be as a result of individual differences and other factors. Cronin-Jones (1991) also found that there are four categories of teachers' beliefs that influenced the curriculum implementation process: beliefs on how students acquire knowledge, beliefs the teachers' have about effective instructional practices, beliefs related to the level of the student's ability in a particular age group, and beliefs about the relative importance of the subject content.

If the individuals are not able or are unwilling to describe their beliefs accurately, this can lead to an error in judging the factors affecting their behaviours (Mansour, 2009). It is hoped that this study will reveal the effect of high-stakes assessment on teachers' beliefs about what it means to teach mathematics effectively. Mansour (2009) remarks that although there is research which indicates that the teachers' instructional practices in the classrooms are affected by their beliefs, there is still a need to examine teachers' beliefs to clarify how they affect their practices. In the domain of mathematics education there is a growing need to study the beliefs of the teachers to understand the factors that influenced their classroom instructional practices and senior secondary school students' performance in high-stakes assessments.

It has been established that teachers' beliefs about effective teaching of mathematics influence their instructional practices (Leatham, 2006; Tella, 2008). These authors are of the view that one's conception of what mathematics is will have an effect on one's conceptions of how it should be presented. Handal and Herrington (2003) also claims that teachers' beliefs may act as a lens through which teachers make their decisions on methods and strategies used in the classroom rather than just relying on their pedagogical knowledge or the curriculum guidelines. At this juncture, it is clear that if teachers strongly hold their beliefs on mathematics subject matter, mathematical knowledge for teaching (MKfT) and pedagogical content knowledge (PCK) (Gierdien, 2008), it will be difficult to change their practices (Handal & Herrington, 2003; Tella, 2008). Therefore, teachers' beliefs about their capabilities and mathematics ability to accomplish task of instructional and assessment practices through their action is fixed ((Tella, 2008). Tella's claims that

what teachers believe about their capability is a strong predictor of their effectiveness. Such beliefs on the demands of WAEC high-stakes examinations can affect the mathematics teachers' instructional and assessment practices.

### **2.11 Teachers' goals for instructional practices and high-stakes assessments**

According to Schoenfeld (2011a) almost all human behaviour is goal-orientated. Teachers respond and react in certain ways to achieve certain goals and they will use their resources during goal-orientated activities in their instructional and assessment practices. Teachers' goals in their instructional and assessment practices can be influenced by high-stakes assessments, just as Popham (2001) observes that some teachers teach to the test for reason best known to them. Goals, knowledge and orientations are artificially divided in this section to focus on each one separately, but in reality they work together. Törner, Rolka, Rösken and Sriraman (2010, p. 409) endorse the comments of a teacher during an interview that "goals and beliefs can hardly be separated" and that they present a "complex network or dependencies". Schoenfeld (2011a) categorizes goals into three types: overarching goals, major instructional goals and local goals. These educational goals are achieved when mathematics teachers use appropriate instructional and assessment practices for students' optimal performance in high-stakes assessments.

From a pedagogical perspective, mathematics teachers' goals are overt (wanting to cover a particular unit of work in a single lesson) or more covert (their overall goals for their students over the academic session). Here goals may include student achievement, student motivation and enjoyment, and teacher satisfaction. Teacher goals are inextricably linked to teacher knowledge and teacher instructional practices. A mathematics teacher may have a specific trajectory in mind that is based on his/her specific knowledge about a mathematical concept (Schoenfeld, 2011a). The teacher may have the disposition towards a certain pedagogical practice (e.g. group work) as a goal if this is part of the teacher's valued knowledge base. The importance of teacher goals is that they impact on a teacher's decision making in his/her instructional practices and provide goals for improving senior secondary school students' performance in high-stakes

assessments. Sometimes goals are not clearly spelled out, because they belong to the affective realm and are set in a greater network of the teacher's orientations.

## **2.12 Teacher orientations**

Schoenfeld (2011a, p. 15) defines orientations “as an inclusive term to encompass beliefs, dispositions, values, tastes and preferences”. So teacher's orientations include what one perceives instructional practices to be, how mathematics should be taught, what students should do that would indicate doing mathematics, and what one would do to be teaching mathematics. Therefore, orientations are dependent on and interdependent with teacher goals and knowledge. Cobb (1986, p. 4) posits that activities carried out by mathematics teachers to achieve goals in their instructional practices are “expressions of beliefs” and that these beliefs can be said to be “assumptions about the nature of reality that underlie goal-orientated activity”. Hence, the mathematics teachers' goals are directed towards effective instructional practices in the mathematics classroom for optimum senior secondary school students' performance in high-stakes assessments.

## **2.13 Mathematics teachers preparatory and assessment practices in Nigeria**

Mathematics teachers adopt different classroom preparatory and assessment practices to evaluate students' learning in the school system and at high-stakes examination body. The teachers spend much of their classroom time engaged in student assessment-related activities. They also control classroom assessment environments by choosing how they assess their students, the frequency of these assessments, and how they give students feedback. All these are clear indications that classroom assessments are an integral part of the instructional practices. Just like any teachers everywhere, Nigerian mathematics teachers are the key drivers of the education process. Their preparatory and classroom assessment practices are the means by which the education system is enhanced and measured (Nenty, Adedoyin, Odili & Major, 2007). Therefore, it is imperative to understand how teachers feel about assessment practices, their perceptions regarding assessment training, and their experiences as they use various assessment methods to evaluate students' learning outcomes.

It is also important to understand their thought processes as they develop and use assessment methods, grade students' work and interpret assessment results. The assessment strategies, grading of students' work and interpreting results are all part of teachers' responsibilities in their classroom instructional practices. They are expected to engage in instructional practices aiming at students' conceptual understanding and equitable access to legitimate mathematical knowledge for all (Schoenfeld, 2017a) and work diligently in their assessment practices. It is inappropriate to focus only on the excessive demands of high-stakes assessments alone. Teachers' assessment practices are an essential element for addressing students' learning needs, and they can ultimately improve the education system and accountability (see section 2.10). Understanding teachers' assessment practices serves as a way of finding out if teachers adopt or use quality assessment methods to meet the learning needs of students (McMillan & Schumacher, 2001). Therefore, senior secondary school mathematics teachers should treat their students equally and fairly in their assessment practices and high-stakes assessments should not influence their instructional and preparatory practices.

Assessment strategies can also be characterized as traditional or alternative in nature. Multiple choice, true/false or matching tests represent traditional approaches to assessment, whereas strategies such as portfolios, journal writing, student self-assessments and performance tools may be considered alternative assessment strategies. Traditional and alternative assessments may be used for diagnostic, formative, guidance-oriented or summative purposes and can apply computing technology for mathematics excellence (Amandi, 2013; Idowu & Esere, 2010). Assessment practices in Nigerian senior secondary schools and WAEC high-stakes examinations are dominated by traditional assessments where objective and open-ended response items are constructed in line with Bloom's taxonomy of educational objectives (Krathwohl, 2002). This part of the study will raise awareness of how Nigerian mathematics teachers generally perceive their classroom and high-stakes assessment practices as well as the fairness of those assessment practices.

## **2.14 Continuous assessment (CA) practices in Nigerian senior secondary schools and in high-stakes assessments**

In the Nigerian context continuous assessment (CA) can take the form of examinations, tests, assignments, practical work and any task set and administered for students by the classroom teacher in order to determine the level of students' achievement (Afemikhe & Omo-Egbekuse, 2010; Birhanu, 2013; FRN, 2013). It could be high-stakes or otherwise. The national steering committee on CA led by Yoloje (1982) regards continuous assessment as a method of ascertaining what a student gains from schooling in terms of knowledge, industry and character development considering their entire performance in tests, assignments, projects and other educational activities during a given period of term, year or the entire period of an educational level. Amandi (2013) and Birhanu (2013) also refer to CA as a comprehensive and systematic process of using relevant assessment techniques and tools to determine the overall progress of students over a period of time. One of the functions of CA is that it helps to address examination tension and anxiety and check malpractice among students (Ukpong & Uko, 2017). This part of review should help the researcher to answer the question: What are the opportunities and challenges faced by Nigerian senior secondary school mathematics teachers and WAEC in the continuous assessment practices?

The introduction of continuous assessment (CA) for evaluation of pupils' and students' performance in mathematics at all levels of schooling is one of the most important and significant developments in the Nigerian educational system in recent times (Afemikhe & Omo-Egbekuse, 2010; FRN, 2004). The policy is taking a central place in the school system, and represents a shift from instructional and preparatory practice for high-stakes examinations to instructional practices toward acquisition of knowledge and skills. By implication, every mathematics teacher from primary to secondary level of education should understand and practise CA. The emphasis on CA is not limited to Nigeria alone; other African countries, for example, Kenya, Zambia, Ghana, and Liberia, have adopted the same policy (Faleye & Adefisoye, 2016). Conceptually as well as in practice, CA provides feedback to students and teachers. Such feedback provides information which is used for purposes of improving on the student's performance or modifying the content, methods and context of instruction, as well as in making a variety of other decisions.

Therefore, this study is investigating how mathematics teachers' instructional, preparatory and assessment practices are influenced by high-stakes assessments.

The national policy on education (FRN, 2004) states the reasons for introducing CA in Nigeria and the disadvantages of the old system of assessments. The reason for introducing CA is to assess the students' performance from the beginning of a level of education to the end. According to the national policy on education, the existing practice of basing the assessment of students work on a final examination, one-shot examination and/or paper and pencil examination (one examination at the end of all instruction and assessing only the cognitive domain) was inadequate and is no longer tenable. The policy document (FRN, 2004) on this structure prescribes CA as a replacement of the orthodox one-shot examinations in schools. Mathematics and science educators thought that students' performance should be determined by systematic assessments (Adeola 2010; Alufohai & Akinlosotu, 2016; Obe, 1983; Ojerinde & Falayajo, 1984; Okpala & Onocha, 1994).

The underlying principle to determine the students' level of achievement is to assess the students' work continuously like the system used in CA in a predetermined ratio to arrive at the final results of a high-stakes examinations. For example, 20% school-based continuous assessment (CA) scores are sent to WAEC during the conduct of WASSCE to form part of the total scores of candidates; these are teacher-made classroom assessments scores. Additionally, it is expected that each teacher in every Nigerian senior secondary school will prepare his/her own continuous assessment tests (CAT). The CAT is used to obtain students' continuous assessment scores (CAS) (Asodike & Jegede, 2010) to be used at school for high-stakes purposes, while the 20% used by WAEC high-stakes examinations forms part of the total scores in the WASSCE Mathematics.

According to the policy, the disadvantages of the old system of assessment is that the mode of assessment was end-of-year examination, or the end-of-course examination at the end of primary, secondary and tertiary education. Many schools have weekly tests or quizzes. These test or quizzes are not usually reflected in the end of the year summary of results. At the end of secondary education, students were made to sit for WAEC high-

stakes examination (Modupe & Sunday, 2015) In certifying the students, therefore, mathematics teachers had little or no input in the assessment procedure. It is amazing that at the senior secondary school level the WAEC high-stakes examining body only involves some teachers in marking the WASSCE annually. This mode of evaluation denied teachers the opportunity of participating fully in the final assessment of their students. It also neglected the assessment of non-cognitive educational objectives (affective and psychomotor domain) and created a lot of social and psychological problems for the students. As part of this study the researcher wants to identify the opportunities and challenges faced by mathematics teachers in their CA practices and the WAEC high-stakes mathematics examinations.

CA strategies can be classified as placement, diagnostic, formative, guidance-oriented and summative (Amandi, 2013; Idowu & Esere, 2010; Ojerinde & Falayajo, 1984; Osadebe, 2015). The way teachers use assessment in their instructional practices in determining their students' level of achievement is a matter of concern. Placement assessment is concerned with testing of an individual at entry point, to ascertain whether he/she will be able to fit in well in the proposed programme of study. Diagnostic assessment strategies are focused on assessing students' prior knowledge, strengths, weaknesses and skill levels. Formative assessments (assessment during instructional practices) are directed at providing immediate feedback and evidence of student progress/performance or lack of it. Guidance-oriented assessments are when assessments data are used by counsellors to give socio-personal and vocational advice to students. Summative assessments (assessment at some logical terminal point) are more comprehensive and are typically administered at the end of a specific timeframe (Amandi, 2013; Idowu & Esere, 2010). These functions cover the assessments at the beginning, during and at the end of the senior secondary school mathematics teachers' instructional practices and the summative assessment is done by the school and by high-stakes examination bodies.

In addition to the earlier definitions, CA can also be described as a mechanism whereby the final grading of a student in cognitive, affective and psychomotor domains takes account of his/her performances over a whole schooling period (Ezewu & Okoye, 1986;

FRN, 2004). These definitions are in line with the characteristics of CA. Therefore, going by these definitions, CA can be defined as a function for building up a cumulative judgment about students' learning activities in terms of knowledge, thinking and reasoning behaviours (cognitive domain), character development (affective domain) and industry or skills (psychomotor domain). The affective and psychomotor domains in senior secondary school mathematics are assessed through their interest and engagement in class activities and their ability to exhibit knowledge and competency in mathematics (Modupe & Sunday, 2015). It is therefore, necessary to examine how well this valuable programme is being implemented by the selected senior secondary schools in Kaduna State. The implementation calls for the utilisation of tests, assignments, projects, practical work, group work and indeed the conventional assessment, otherwise called authentic, techniques.

CA strategies can be classified according to their functions, such as for placement, diagnostic, formative, guidance-oriented and summative use (McMillan, 2008). The way teachers use assessment in their instructional practices is a major variable in determining student achievement in the senior secondary school mathematics classrooms and at WAEC high-stakes examinations. Placement assessment is concerned with testing of an individual's entry behaviour so that he/she will be able to fit well into the proposed programme of study. Diagnostic assessment focused on assessing students' prior knowledge, strengths, weaknesses and skill levels that could determine the appropriate strategies to employ in the teacher's instructional planning. Formative assessments (assessment during instructional practices) are directed at providing immediate feedback and evidence of student progress/performance or lack of it. Guidance-oriented assessments take place when assessment data are used by counsellors to give socio-personal and vocational advice to students. Summative assessments (assessment at some logical terminal point) are more comprehensive and are typically administered at the end of a specific unit or timeframe.

Modupe and Sunday (2015) studied teachers' perception and implementation of CA practices in secondary schools in Ekiti-State, Nigeria. It was found that teachers did not adhere to the NPE's prescribed principles of CA, which spelt out that students should be

evaluated in the three domains of educational objectives (cognitive, affective and psychomotor domain). It was recommended that government should organize seminars, conferences and workshops for teachers on the correct implementation of CA in secondary schools. Therefore, there is a need for continuous professional development (CPD) for mathematics teachers to meet the demands of CA in the Nigerian senior secondary schools, because this is the level of education where CA form part of the students' total scores in the WASSCE high-stakes examinations administered by WAEC.

Furthermore, right from the introduction of CA as part of assessment in schools the different state governments in Nigeria worked out implementation guides which in most cases reflected what was contained in a handbook *Continuous assessment: A new approach* written by Ojerinde and Falayajo (1984). Experience shows that almost all of the implementation guidelines stipulate that tests be administered twice every school term in addition to an end of term examination. The tests and examinations are to be combined in the ratio: 15:15:70, i.e. 15% assessment of student tests, 15% assignments and other activities of the term, 70% end-of-term examination. At the end of the year the results for the first two terms' examinations and the third term examinations are also combined in the ratio: 15:15:70. The performance in the last term of the year is generally used to decide on students' progression in many state-owned schools. Information on the psychomotor and affective domains (non-cognitive domains) is also supposed to be collected, but is not generally combined with scores on the tests and school examinations. There are no item banks available from which the respective tests are drawn; different teachers construct their own tests and examinations, though one may notice pockets of states that administer state examinations.

CA is a helpful tool in assessment practices in Nigerian senior secondary schools, in that it is characterized by being systematic, comprehensive, diagnostic, cumulative and guidance oriented (Idowu & Esere, 2010; Ojerinde & Falayajo, 1984). The basic nature of CA is five-fold. First, the systematic nature of CA: the teacher has to ensure that different assessment techniques are employed at different times in the quest for CA. This will take care of whatever inadequacy that could have been assessed by the students' inability to maximally express their prowess when a particular assessment technique (e.g.

a test) is used. For example, a student who has a fear of tests could make up for his/her inadequacy in other activities like projects or take-home assignments. According to Idowu and Esere (2010) and Ojerinde and Falayajo (1984), the systematic nature in this strand implies that the teachers will have to conduct a series of assessment activities at different stages of their classroom instructional practices.

Second, the comprehensive nature of CA demands that the assessment activity of the teacher is expected to cover the cognitive, affective and psychomotor domains of the students' behaviour. This means that the teacher should not narrow his/her assessment activity to issues relating only to paper and pencil methods of assessing the students' achievement in mathematics, but should also extend mathematics assessment to such activities like the use of hand and brain (through the coordination of muscles and bones) to produce things that are observable (Faleye & Afolabi, 2007). The affective activities could be students' engagement in mathematics activities in the class. Examples of psychomotor activities include drawing graphs and tables, and constructing shapes in construction and loci during class work and answering such questions in WAEC high-stakes mathematics examinations.

Third, the diagnostic nature of CA: the teacher in his/her assessment practices diagnoses the strengths and the weaknesses of the students. The teacher is expected to facilitate the consolidation of the areas of students' strength in learning and at the same time plan remediation for mitigation of the weaknesses (The brilliant students are encouraged to work harder, and weak ones are given remedial attention for improvement).

Fourth, the cumulative nature of CA necessitates that the average continuous assessment scores (CAS) of every student in a particular session are carried over to the next class level until the last class of the school level. For example, senior secondary school 1 (SSS1) CAS are carried over to senior secondary school 2 (SSS2), then SSS2 CAS are carried over to senior secondary school 3 (SSS3) cumulatively to obtain the final 20% for WAEC's WASSCE. This is to ensure that the students do not face the disadvantage of any teacher who may not be forthright in the administration of CA for any particular school level (Faleye & Adefisoye, 2016). Therefore, the final CAS of any student at any level of schooling are the composite of all the CAS obtained from time to time in a

particular term, year and the entire level of education. The question is: how valid and fair are these CA practices in Kaduna State senior secondary school mathematics classrooms and at WAEC high-stakes examinations? What are the opportunities and challenges?

The fifth feature of CA is that it is guidance oriented. It is expected that feedback is obtained after assessment activity in the school and the information so collected is to be used for educational, vocational and personal-social decision-making for the student. The feedback also serves as a lens to the parents/guardians who are concerned about their children's progress at school. If the teacher could not help the students in their areas of weaknesses, the students concerned are expected to be referred to the school counsellor for help, or even to the parents or guardians for assistance. These five characteristics of CA are supposed to guide the senior secondary school mathematics teachers in their assessment practices.

Idowu and Esere's (2010) study of CA practices in Nigerian schools attempted to evaluate CA practices in ten selected Nigerian secondary schools within the Ilorin metropolis. It was a qualitative study and the data were collected through interviews and focus group discussions which centred on the teachers' CA practices based on the five basic attributes that characterise continuous assessment. The result of the findings showed that the CA practices of most of the teachers were faulty and deviated markedly from policy guidelines. It was recommended that in-service training be organised for secondary school teachers in Nigeria to orient them more on CA guidelines as spelled out in NPE for the attainment of the overall educational goals. However, the findings from ten selected secondary schools within the Ilorin metropolis are not enough to draw conclusions or generalize about the entire Nigerian NPE. Therefore, more empirical studies are required to confirm the results of this study.

In her presentation on ensuring fairness in the CA component of school-based assessment (SBA) practice in Nigeria, Onjewu (2007) observed that there are inherent problems with the derivation of CA scores and the situation deserves the attention of academics. The author further argued that the entire practice of CA is characterised by laxity: laxity in timing, laxity in terms of the mode that the CA exercise takes, and laxity in

relation to the content of CA. The continuous assessment scores (CAS) per se have generated a lot of controversies between schools and examination bodies such as the West African Examinations Council (WAEC). Schools are accusing examination bodies of not using the CAS sent to them, while the examination bodies are in turn accusing the schools of inflating the CAS sent by them. This attests to the fact that there is no uniformity in the practices of CA and hence the need to devise a means of making the CA scores compatible and comparable in practice.

Additionally, there appears to be a shift from the principles of CA in practice. Not only this, but there also seems to be a discrepancy between the CA policy and actual practices. Many schools have embarked on the implementation of CA. It is not surprising therefore, to find mathematics teachers assessing their students weekly, at the end of each unit or module, amongst other times. In recent times, however, these assessments have assumed disciplinary status to check noisiness and truancy, amongst other things. At this juncture CA in practice ceases to be a tool for aiding learning. One can only call it what it is “continuous testing”, which is contrary to the definition of continuous assessment (Ezewu & Okoye, 1986). The Nigerian NPE is expected to be respected by Nigerian senior secondary school mathematics teachers in order to match the demands of classroom assessments and the WAEC high-stakes assessments in mathematics.

Therefore, the CA committee in every school is expected to plan the schedule of assessment activities for the school year or term. The Vice-Principal (Academic) is expected to serve as the chairperson of the CA committee, while the school counsellor serves as the secretary and custodian of all CAS in the school (FRN, 2004). It is the responsibility of the committee to identify the assessment activities for the term and articulate them clearly for every teacher in the school, usually at the start of the term or session.

Kwawukume (2006) points out that a study of the WAEC high-stakes examination in Ghana investigated the validity and reliability of the continuous assessment score (CAS). The findings indicated that generally some teachers abused the CAS. The study further established that CAS in certain subjects obtained by some students did not have any positive relationship with the scores obtained in the high-stakes examinations.

As mentioned earlier, at the senior secondary school level CA is given 20% in the WAEC high-stakes mathematics examination in the WASSCE process. WAEC uses a statistical approach to moderate the CA scores which are school-based assessments (SBA) submitted by the schools and based upon 20 marks which are generated from senior secondary school one to three (SSS I to SSS III) before incorporating them into the certification grades of the WASSCE (JAMB, 2009; WAEC, 2015). The raw scores (CA) submitted by the schools are aggregated by WAEC to obtain Actual Aggregate of Continuous Assessment (AACCA) Scores. However, WAEC moderates the AACCA scores statistically to arrive at a Moderated Aggregate of the Continuous Assessment (MACA), which is finally incorporated into the certification scores (final scores), which are the total of MACA and examination scores, that is, 20% CA from schools plus 80% WASSCE Scores 80% equals 100% scores (JAMB, 2009). It seems reasonable for WAEC high-stakes examination not to accept SBA scores without moderating them. However, the question is: how do these CA practices in WAEC affect mathematics teachers' instructional, preparatory and continuous assessment practices?

Adamolekun, (1984) and Omowaye (2002) report that schools and/or teachers in their assessment practices can and do deliberately inflate the scores and grades of their students to ensure their success, no matter the scores or grades they receive in the final high-stakes examinations. Abass (2000) observed that candidates' CA scores may not be the true reflection of their ability they he might be scored higher than their actual ability. This may be done for many reasons such as special interest in such candidates. These teachers may think they are helping these students by inflating the scores, not knowing that the students are at a disadvantage rather than being advantageous for them. More so, inflated scores/grades, according to Juola (1976) provide inaccurate feedback, which may represent intellectual dishonesty. Chapelle and Douglas (1993) support the argument that the CA approach can help to rectify the problem of mismatches between test and classroom activities.

From the review of the literature above one can deduce that assessment practices in the mathematics classroom and at high-stakes assessments level have no universal procedure or proper coordination in practice. The individual teachers and WAEC high-

stakes examination agencies determine how much a student earns in terms of academic performance. The assessment practices are sometimes susceptible to cheating by students, teachers, principals, parents and other stakeholders. How WAEC harmonized the SBA with the WASSCE and how fair the practices are is unknown. Therefore, part of this study verifies how WAEC high-stakes examinations influence mathematics teachers' assessment practices in the selected Kaduna State senior secondary schools.

### **2.15 Fair assessment practices in senior secondary schools and WAEC high-stakes examinations**

Fair assessment practices mean that all students are given equitable opportunities to demonstrate what they know (Lam, 1995; Schoenfeld, 2017a) – provided that the students are taught under the same conditions and are assessed equally under the same conditions, regardless of race, home background, access to learning resources, and language differences. Does equitable assessment mean that all students should be treated exactly the same by mathematics teachers in their assessment practices? Schoenfeld (2017a) explains that equitable assessment means that students are assessed using methods and procedures most appropriate to them. These may vary from one student to the other, depending on the student's prior knowledge, cultural experience and cognitive style. Creating custom-tailored assessments for each student is, of course, largely impractical, but nevertheless there are steps teachers can take to make their assessment practices as fair as possible. If teachers are to draw reasonably good conclusions about what senior secondary school students have learned, it is imperative that they make assessments and use the results as fairly as possible for as many students as possible.

### **2.16 Challenges faced by senior secondary school mathematics teachers and WAEC high-stakes examination in implementing continuous assessment**

Challenges are the problems of implementing continuous assessment programmes in Nigerian senior secondary schools (Omo-Egbekuse, Afemikhe, & Imobekhai, 2010; Osunde, 2008). The fact is that there is no universally agreed implementation guide and procedure across the country. Obanya (1979) and Afemikhe (1990, 2000, 2007) describe the implementation as a caricature. According to Osunde (2008), some of the Nigerian

senior secondary school teachers lack adequate skills to develop, validate and administer the school-based assessments (SBA) which normally form part of the final scores in WAEC's WASSCE. Senior secondary school mathematics teachers should rise to the occasion to ensure implementation of the proper CA practices in mathematics, given the sensitive nature of the CA in relation to SBA and high-stakes assessments.

In their study of teacher assessment competencies Omo-Egbekuse et al. (2010) found that many teachers claimed that they are competent on almost all issues raised, but experience in the field showed that there was no match between what was claimed and what was observed. The research yielded reliable scores, but lacked experiential validity. The situation was compounded by lack of uniformity in standards for implementation across schools; therefore, there was a problem of comparability of the scores of students from different schools.

Closely allied to this problem is the faking of the continuous assessment scores (CAS) that the WAEC high-stakes examinations body require in their WASSCE (Afemikhe & Omo-Egbekuse, 2011). This trend is not unconnected with the obsession to pass examinations at all costs. A situation like this casts doubt on the classroom assessments from which the continuous assessments are generated. Examination boards are then given the added burden of trying to remove inconsistencies from the scores submitted. Afemikhe and Omo-Egbekuse (2010) lament that one ugly trend is a situation where tests are not administered, even though the policy states that there must be two tests in a term, but scores awarded anyway. More so, the attitude of senior secondary school teachers towards the implementation of CA and record keeping is questionable.

Furthermore, at the primary, secondary and tertiary levels of education in Nigeria, CAS are incorporated or expected to be incorporated into the terminal assessment score (TAS) and there is growing concern from students, teachers, parents and some stakeholders about how effectively this is being done (Afemikhe, 2007). The terminal assessment particularly that conducted by West African Examinations Council (WAEC), has uniform items for each student across all schools in Nigeria. This enhances comparability of raw scores. But in the CA situation, the comparison of raw scores from various schools is difficult and no reasonable measures have been taken to rectify this anomaly. The

implementation of CA in Nigeria is one of the major functions of the teachers. The teachers' inability to effectively put CA into practice may have caused some lapses in the grading, interpreting and reporting of students' performance. According to Afemikhe (2007), pupils/students progression from primary to secondary level in some schools is now seen as automatic, because they now move at will from one school to another without their CA profiles, which ought to be part of such movement. As mentioned earlier, many schools that admit such students fake their CAS, which are sent to examination bodies (Afemikhe, 2007). Afemikhe further contends that this act to some extent constitutes pre-examination malpractice. One of the rationales for the introduction of continuous assessment was reduction of the incidence of examination malpractice, but the ability to implement this underlying reason seems elusive because the intensity of examination malpractice is at the increase.

Additionally, CAS generated by such teachers are nothing but continuous testing scores (Faleye & Adefisoye, 2016; Faleye, 2005). The scores themselves may not be regarded as continuous testing results, because the tests are usually conducted twice (or even thrice) in each term. Faleye and Adefisoye (2016) emphasize that this practice negates the opportunity which CA seeks to provide to the senior secondary school students in Nigeria. Senior secondary school administrators and high-stakes examination bodies like WAEC are supposed to ensure that the CAS are based on standardized/uniform test types and content. They should also ensure uniform administration procedures through effective monitoring and moderation processes.

## **2.17 Statistical analysis of student achievement in mathematics assessments**

Assessment information can help teachers understand how they should construct classroom assessments for evaluating students' learning (McMillan, Myran & Workman, 2002). Teachers need to have basic knowledge of how to collect, analyse and interpret assessment information to make informed decisions. They should have knowledge of computing the student CA during the term, at the end of the term, at the end of each year of from SSS1 to SSS3 and arriving at the 20% CA that is sent to WAEC high-stakes examination as part of the scores in the students' WASSCE. What should be realized is that ideally the classroom assessment information that teachers collect does not only

benefit students, but also helps teachers to evaluate the effectiveness of their instructional practices. Mathematics teachers in their assessment practices need to have the basic statistical competencies to compile and tally the senior secondary school students' results termly, yearly and cumulatively (Guskey, 2003). These statistical competencies may help in reducing the controversies around the faking of CA scores sent to WAEC high-stakes examinations.

### **2.18 Effects of high-stakes assessments on instructional and assessment practices**

The evidence gleaned from the empirical literature suggests that high-stakes assessment has an effect on teachers, students, administrators, the education system and society in general (Agbeti, 2011; Stobart, 2008). These stakeholders concerned with assessments in the school system do not exist in isolation. In practice, assessment practices are products of the interaction between the mathematics teacher and students in the Nigerian senior secondary school classrooms which are managed by administrators as part of the education system in line with society's expectations of the school. The school instructional and assessment practices respond to societal demands.

One of the observable effects of high-stakes assessment mathematics teachers' instructional and assessment practices is that teachers tend to teach only content that is expected in the examination (Julie, 2013a; Popham, 2001a, 2013b). Mathematics content that in the estimation of the teacher or students will not be on the test is ignored, even if it is in the curriculum, or topics that are not tested receive little or no attention (Firestone et al., 2000). In this situation the instructional and assessment practices are regarded as teaching to the test and not teaching to the curriculum (i.e. for knowledge and skills). Hence, the aims of instructional and assessment practices in the senior secondary school students' mathematics for knowledge and skills are defeated.

Wideen, O'Shea, Pye and Ivany (1997) studied the influence of a high-stakes examination in British Columbia, Canada to identify the way teachers taught science in Grade 12, which was the final examination class and compared it with teaching in Grades 8 and 10. Their findings were that the high-stakes examinations influence teachers' instructional practices. In the classes preceding the final examination class, teachers were found to be

more willing to deviate from the curriculum and they ventured into trying different approaches to the teaching of science, while the classes were conducted at a more leisurely pace. However, in the final examination classes, the ambience was different as the researchers sensed a strong need to process a large number of topics expected in the examination. The single-mindedness of the enterprise was underscored by the impatience that students demonstrated when the teacher withheld answers or ventured into territory that would not appear on the expected examinations.

Minarechová (2012) studied the negative effect of high-stakes assessments on students, teachers, administrators and policymakers. The study aimed at explaining the concept of high-stakes assessments, and how it is created and developed in selected countries (Slovakia, the Czech Republic and Romania) and looked at the negative effects of assessments on instructional practices. However, this study focuses on mathematics teachers' instructional practices only and not on students, administrators or policy makers. The findings show that high-stakes examinations encourage teachers to focus more on specific test content than on curriculum standards; they lead teachers to engage in inappropriate test preparation; this devalues teachers' sense of professional worth, causes students' stress and encourages teachers to cheat when preparing or administering tests.

### **2.19 Professional development as an opportunity for mathematics teachers to cope with challenges of classroom instructional and assessment practices for high-stakes assessments**

Professional development (PD) gives opportunities to teachers (including mathematics teachers) to update their knowledge and improve their proficiency in instructional and assessment practices (Ejima & Okutachi, 2012; Oluremi, 2013, 2015; Ndlovu, 2014). Continuous professional development helps the teachers in multiple ways. It updates their SMK, PCK and CCK (Ball *et al.*, 2008) as well as presenting new instructional strategies and effective preparation of students for high-stakes assessments. For Nigeria to align itself with the global trends, individuals who understand their responsibilities and exercise their rights as democratic citizens, the need to update mathematics teachers' knowledge through continuous professional development (CPD) programmes is necessary. In recognition of the above, the Teachers Registration Council of Nigeria (TRCN) was

established in 1993 through the TRCN Act 31 of May 1999. The establishment of the TRCN was expected to mark the beginning of a new era in recognising the professional status of teaching, articulating the vision of teacher education and ensuring its proper coordination in Nigeria. It was also expected that the TRCN would provide all teachers with the opportunity for continuous development in order for them to remain significant as professionals in the present age of globalisation (Oluremi, 2013, 2015). However, Ejima and Okutachi (2012) report that a lack of governments' commitment and the inability of the TRCN to regulate the teaching profession have marred the quality of the teaching force in Nigeria. One of the major shortcomings of the TRCN as observed by Ejima and Okutachi (2012) is the inability of the body to implement the National Minimum Standards (NMS) for education and execution of Mandatory Continuing Professional Development (MCPD), both of which are meant to ensure that teachers are well informed about changes in the theory and practice of the profession, and most importantly the development of democratic citizens in their classroom instructional practices. Mathematics teachers in Nigerian senior secondary schools are not left out of this policy implementation.

## **2.20 The missing link in the literature**

Literature on the effect of high-stakes assessments on instructional practices generally appears to be scarce in West Africa and Nigeria in particular. More literature was found on the effect of high-stakes assessments on general assessment and continuous assessment (CA) practices (Afemikhe & Omo-Egbekuse, 2010; Agheti, 2011; Birhanu, 2013; FRN, 2013; Esere & Idowu, 2013; Oguneeye, 2002; Omo-Egbekuse et al., 2010). It addressed neither senior secondary schools specifically nor mathematics. Most of the studies are from developed countries, where the mathematics curriculum is slightly different from that of developing countries. Is it possible to apply what is practised in developed countries to developing countries? The study would like to find out whether senior secondary school mathematics teachers' instructional, preparatory and assessment practices are influenced by WAEC high-stakes examinations. How fairly does the WAEC high-stakes examination body use the schools' CA as part of the final scores of students in the WASSCE? For example, if a student has high CA scores and

performs poorly in the WASSCE or has low CA and performed very weak in WASSCE, how are these results reconciled in the WAEC high-stakes assessment practices? Or what formula is used to ensure fairness in the practices?

There is a complex relationship between high-stakes assessment practices and mathematics instructional practices, and mathematics teachers' beliefs are relevant to their effectiveness. Mathematics teachers' beliefs play a mediating role in the relationship between teachers' mathematical knowledge and their instructional practices. There is no literature that spelt out clearly the significance of mathematics beliefs about what it means to teach mathematics effectively in Nigerian senior secondary schools. There is a lack of detailed understanding of how mathematics teachers' beliefs affect student learning and how their instructional practices mediate the effects of high-stakes assessments on student performance in the WASSCE. Additionally, the mathematics teachers' task choices and approaches appeared to be confounded by teacher-centred, lecture-based and textbook-bound (i.e. traditional) methods instead of the student-centred approach required in their instructional practices. What are the current beliefs and approach in mathematics teachers' instructional practices? If the approach is the same, what can be done to make an improvement?

The opportunities of senior secondary school mathematics teachers are their involvement in the assessment of their students and continuous professional development. Therefore, they need to constantly update their knowledge through professional development. The Teacher Registration Council of Nigeria (TRCN) and the Mathematical Centre, Abuja has the responsibility of continuous professional development (CPD) (training and re-training) of mathematics teachers at all levels of education in Nigeria. There is no literature about the activities of TRCN. What does a mathematics teacher gain from his profession apart from the salary? What are the current challenges faced by the mathematics teachers in their instructional, preparatory and assessment practices with respect to school-based assessment (SBA) and WAEC high-stakes examinations?

## 2.21 Conclusion

This chapter reviewed some of the literature relevant to this study. This included literature on how high-stakes assessments influence mathematics teachers' instructional, preparatory and assessment practices, and mathematics teachers' beliefs about what it means to teach mathematics effectively. Related concepts on mathematics teacher effectiveness in their instructional practices such as teachers' knowledge, self-efficacy and beliefs were reviewed. Opportunities (e.g. professional development) and the challenges facing senior secondary school mathematics teachers and high-stakes on continuous assessments (CA) were also reviewed. The mathematics teachers' knowledge, goals, efficacy, beliefs, and human and material resources are seen in this study as educational constructs for senior secondary school mathematics instructional and assessment practices. The senior secondary school mathematics curriculum, WAEC syllabus and other learning materials are the material resources. Some teachers do not see the need for a curriculum and other instructional materials in their instructional and assessment practices; they prefer just to get the students ready to take the high-stakes examinations through examination-driven instruction (Joseph et al., 2011). Hence, the washback effect on students' educational experiences, creating inequality of school resources and opportunities, and devaluing teachers as professionals.

The next chapter discusses the theoretical and conceptual frameworks and history of education in Nigeria.

## CHAPTER 3

### THEORETICAL AND CONCEPTUAL FRAMEWORKS

#### 3.1 Introduction

This chapter deals with the theoretical and conceptual frameworks that are relevant to effective mathematics teachers' instructional and assessment practices, and how these practices are influenced by the West African Examination Council (WAEC) high-stakes examinations in mathematics West African Senior School Examination (WASSCE). The theoretical frameworks for this study are underpinned by Popham (2001, 2003a, 2004), the instructional and assessment practices described by Schoenfeld (1992, 2016, 2017a, 2017b), the framework of teaching for robust understanding (TRU) and Bloom, Engelhart, Frust, Hill and Krathwohl's (1956) taxonomy.

For this study, the theoretical frameworks are in the context of qualitative ethnographic case study which are based on particular theories explaining them. Theories are systematic explanations for the observations that relate to a particular aspect of life (Babbie & Mouton, 2001). A conceptual framework refers to the entire processes involved in a particular study (Leshem & Trafford, 2007). In short, it is the roadmap of the study. Therefore, theoretical and conceptual frameworks, which are represented as models, help in driving this empirical study and provide both direction and impetus. The models are represented in Figures 3.1, 3.2 and 3.3.

On the one hand, a theoretical framework focuses on a theory or theories used in the study, and shows the relationships between the theory or theories and the study (Merriam & Tisdell, 2016). The theoretical frameworks for this study provide a structure for conceptualizing how Kaduna State senior secondary school mathematics teachers' instructional practices and strategies are affected by high-stakes assessments. On the other hand, a conceptual framework focuses on concepts used in the study, draws on key concepts which could come from various theories and shows the relationship between the concepts and the study (Leshem & Trafford, 2007). The three theoretical frameworks serve as a lens for this study to investigate the impact of high-stakes assessments on teachers' instructional and assessment practices in mathematics. The conceptual

framework is a schematic (conceptual) representation of the relationship between mathematics instructional, preparatory and assessment practices in Kaduna State senior secondary schools and the high-stakes assessments.

### **3.2 Theoretical frameworks**

The theoretical framework is the underlying structure of a study consisting of theories that inform the study (Merriam & Tisdell, 2016). Therefore, mathematics teachers' instructional practices cannot be effective unless grounded in theories, no matter how limited or small-scale such theories are (Fosnot, 2005; Orton, 2004). Theories are also useful in research because they direct researchers' attention to particular relationships, provide meaning for the phenomena being studied, help researchers rate the relative importance of the research questions they ask, and place findings from individual studies within a larger context (Hiebert & Grouws, 2007; Orton, 2004). This qualitative ethnographic case study investigated the Kaduna State senior secondary school mathematics teachers' instructional practices as the most significant elements in overarching theories that determine the classroom culture in a natural setting.

Therefore, the theories adopted for this study suggest line of action when formulating the research questions and provide a scheme within which to accumulate and put together individual sets of results (Hiebert & Grouws, 2007). They determine and define the focus and the goal of the research problem. As mentioned earlier, the overarching theoretical frameworks chosen to underlie effective instructional and assessment practices in this study are: Popham (2001, 2003b, 2004) framework of instructional and assessment practices, Schoenfeld (1992, 2016, 2017a) framework of teaching for robust understanding (TRU) of mathematics and framework of Bloom's taxonomy (Bloom et al., 1956; Krathwohl, 2002). The three theoretical frameworks in Figure 3.1 act as an interpretive lens for the study.

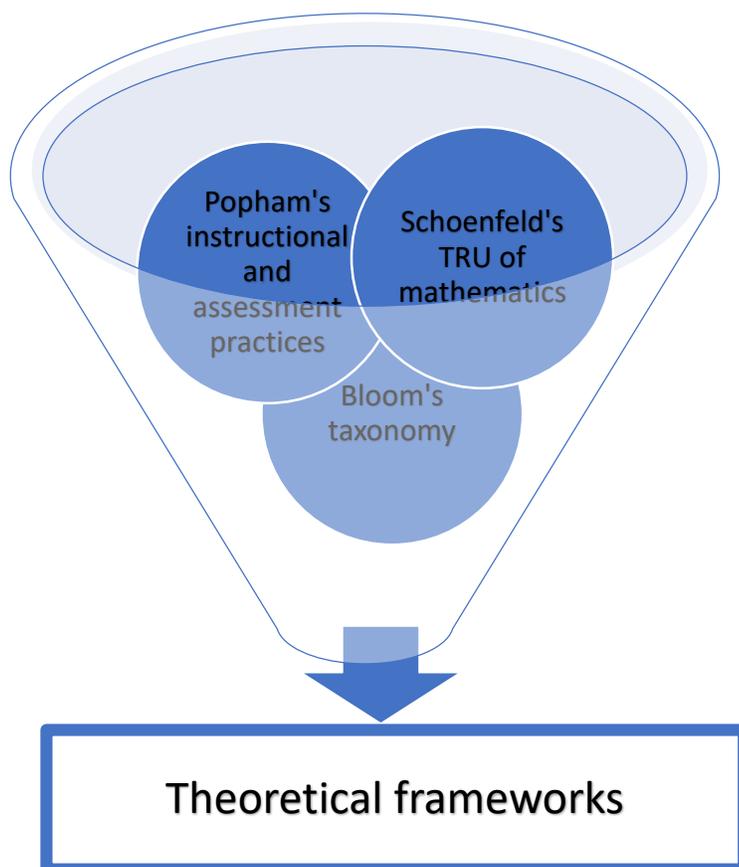


Figure 3.1: Theoretical frameworks for the study

Figure 3.1 show the three theoretical frameworks that underpin this study. Popham's instructional and assessment practices; Schoenfeld's framework of teaching for robust understanding (TRU) and Bloom's taxonomy overlap at the level of teachers' instructional practices and assessment practices. The three frameworks emphasized the effective instructional practices for conceptual understanding, making sense of mathematics and teaching to the curriculum (Popham, 2001, 2003b, 2004; Schoenfeld, 1992, 2016, 2017a; Bloom et al., 1956; Krathwohl, 2002). The frameworks also make provisions for ways mathematics teachers in their instructional practices to take cognizance of the cognitive levels of the students when planning their lessons in order to engage the students in classroom activities that will promote factual and metacognitive knowledge. Additionally, the Nation policy of education (FRN, 2014), the national mathematics curriculum (NERDC, 2007) and the WAEC high-stakes mathematics examinations (WAEC, 2014)

encourage the use of the six cognitive levels (remembering, understanding, applying, analysing, evaluating and creating) in preparation of classroom instruction and assessment of students in Nigerian senior secondary schools.

In teachers' assessment practices, the three frameworks indicate formative and summative assessments at all levels of education (Popham, 2001, 2004; Schoenfeld, 1992, 2016; Bloom et al., 1956; Krathwohl, 2002). The formative assessment includes all the school-based continuous assessments, while the summative assessments are examinations taken at the end of a programme. They are sometimes call high-stakes assessments administered at the end of every level of education for significant educational decisions on students, teachers and the schools as well as about graduation, selection and placement of students in the next level of education (Aysel, 2012; Heubert, 2000; Smyth, Banks & Calvert, 2011). The three frameworks underpin the study as a lens to see whether the principles and practices of teaching mathematics adopted in developed countries can be implemented in developing countries such as Nigeria. The three frameworks also address the principle of teaching to the curriculum, teaching for robust understanding and teaching for credible assessments. Conclusively, all of them are at the core of effective instructional and assessment practices.

### **3.2.1 Popham' framework for mathematics teachers' instructional and assessment practices**

This study first adapted Popham's (2001, 2003b, 2004) framework of mathematics teachers' instructional and assessment practices in conjunction with an analysis of the content and cognitive level of the students aligned between the intended/taught and the assessed senior secondary school mathematics curriculum (Ben-Yunusa, 2008; Ndlovu & Mji, 2012) in relation to the high-stakes exit-level examinations. This framework helps the researcher understand mathematics teachers' instructional practices, pedagogical beliefs and preparatory practices for WAEC high-stakes examinations. Popham (2001b) distinguishes between item-teaching and curriculum-teaching. In item-teaching, teachers organize their teaching either around the actual items found in a test or around a set of look-alike items while curriculum-teaching means teaching for conceptual understanding or teaching to the knowledge and skills prescribed in the curriculum (teaching that is

directed at the curricular content represented by test items). Focusing on the latter will enhance students' performance in high-stakes assessments, their mastery of skills on which the test items are based, and their ability to use mathematics in day-to-day activities (Popham, 2001b). Popham's goal is to guide the teachers to an understanding of the misuses of high-stakes examinations, and to develop the insight to distinguish between tests that are instructionally useful and those that are not. He observed the negative consequences of the current high-stakes assessments policies on classroom mathematics instructional practices. Such negative effects of high-stakes assessments are the teachers' instructional practices that focus on assessment scores instead of actual learning, misidentification of effective and ineffective schools, and reduction of the curriculum to cover only test content. Such practices are described by Julie (2013a) as examination-driven instruction.

Based on Popham's extensive experience as an educator and test developer, and his expertise in educational measurement, he provides a step-by-step analysis of the serious problems around current use of high-stakes assessments. Popham also gave a historical account of how high-stakes tests gained their current position as the ultimate means of evaluating teachers' effectiveness in their instructional and assessment practices. According to Popham (2003), teachers and high-stakes examinations bodies (like WAEC) can generate scores from assessments if they know how to design instructionally useful assessments. Popham (2001, 2003b, 2004) further outlined five attributes of an instructionally useful test: its significance, teachability, describability, reportability and non-intrusiveness (see Figure 3.2).

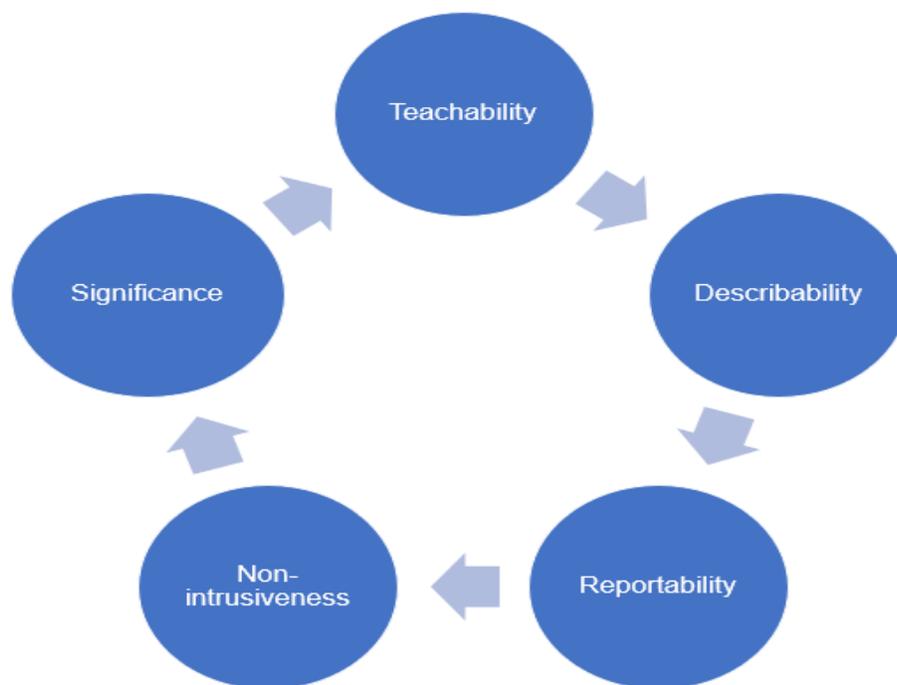


Figure 3.2: Popham's five attributes of an instructionally useful assessment (adapted from Popham, 2003b, p. 49)

Significance is concerned with instructionally useful assessment that measures students' attainment of a worthwhile knowledge. This attribute should answer the question: Do senior secondary school mathematics classroom and high-stakes assessments measure genuinely worthwhile of knowledge and skills? Teachability means that most teachers, if they deliver reasonably effective instruction aimed at the test's assessment targets, can get most of their students to master what the test measures. Describability means the assessment is directly based on sufficiently clear descriptions of the skills and knowledge it measures, so that teachers can design properly focused instructional activities. Reportability means assessment yields results that clearly inform teachers about the effectiveness of their instructional practices. Non-intrusiveness signifies not spending more time on assessment practices than on instructional practices. According to (Popham, 2003b), instructionally useful assessment should not take too long to administer, and it should not intrude excessively on instructional activities. This is where the mathematics teacher should ask him/herself: Do preparatory and high-stakes assessment practices take too much time away from the classroom instructional

practices? The answers to these questions will vary from teacher to teacher. These perspectives are important for day-to-day effective teaching and meaningful learning of mathematics to ensure senior secondary school students' success both in the classroom assessments and in high-stakes assessments.

### **3.2.2 Schoenfeld's framework of teaching for robust understanding (TRU), sense making in mathematics and balanced assessment**

The current study is also underpinned by Schoenfeld framework of teaching for robust understanding (TRU), sense making in mathematics and balanced assessment which puts the emphasis on effective mathematics teachers' instructional and assessment practices (Schoenfeld, 1992, 2016, 2017a, 2017b). The framework of teaching for robust understanding has developed a collection of tools for mathematics teachers to support and improve teaching at all levels of education (Schoenfeld, 1992, 2016, 2017a, 2017b). The five dimensions of powerful mathematics teachers' classroom instructional and assessment practices were outlined by Schoenfeld (2017a) as: content; cognitive demand; equitable access to content; agency, ownership and identity; and formative assessment. These dimensions are best practices that can also be expected from Nigerian senior secondary schools as they focus on what really counts in powerful mathematics classroom instructional and assessment practices. The five levels are illustrated in Table 3.1.

Table 3.1: The five dimensions of powerful mathematics classroom (Schoenfeld, 2017a, p. 1)

<b>Dimension 1: The Mathematics Content</b>
The extent to which classroom activity structures provide opportunities for students to become knowledgeable flexible and resourceful mathematics thinkers. Discussions are focused and coherent providing opportunities to learn mathematical ideas, techniques and perspectives, make connections and develop productive mathematical habits of mind.
<b>Dimension 2: Cognitive Demand</b>
The extent to which students have the opportunities to grapple with and make sense of important mathematical ideas and their use. Students learn best when they are challenged in ways that provide room and support for growth with tasks difficulty ranging from moderate to demanding. The level of challenge should be conducive to what has been called “productive struggle”.
<b>Dimension 3: Equitable Access to Mathematics</b>
The extent to which classroom activity structures invite and support the active engagement of all of the students in the classroom with the core content being addressed by the class. Classroom in which a class in which a small number of students get most of the “air time” is not equitable, no matter how rich the content all students need to be involved in meaningful ways.
<b>Dimension 4: Agency, Ownership and Identity</b>
The extent to which students have the opportunities to “walk the walk and talk the talk” -to contribute to conversation about mathematical ideas, to build on others’ ideas and have others build on them, in ways that contribute to their development of agency (the willingness to engage) their ownership over content and the develop active identities as thinkers and learners.
<b>Dimension 5: Assessment practices</b>
The extent to which classroom activities elicit students thinking and subsequence instruction, responds to these ideas, build on productive beginning and addressing emerging misunderstandings, powerful instruction “meets students where they are”, and gives them opportunities to deepen their understandings.

Table 3.1 shows the first dimension is the mathematics content, which is concerned with the main ideas of the lesson, and the connection between the present lesson and the previous knowledge of the students. It also refers to the ways mathematics teachers can enrich the task to provide learners with opportunities to grapple with mathematics

activities and to develop a productive mathematical mind-set for high-stakes mathematics assessments.

The second dimension is the cognitive demand. This is the concern with the length of time the students think and make sense of the content of mathematics during classroom instructional practices and what happens when the students get stuck in the learning process. This also determines whether the students are expected to give explanation or just to produce answers. According to Schoenfeld (2017a), providing students with opportunities to do mathematics enables them to make their own sense of mathematical ideas by formulating situations mathematically, employing mathematical concepts, facts, procedures and reasoning as well as reflecting on the mathematical solutions or conclusions. This is an opportunity that mathematics teachers should grab in their instructional and assessment practices in preparing the Nigerian senior secondary school students for WAEC high-stakes mathematics examinations.

The third dimension is equitable access to mathematics content. Schoenfeld (2017a) contends that equitable access to content is the possibility of students getting to participate in meaningful mathematics learning and the way the students can be engaged in the lesson. The question is about who participates in the mathematical work of the class, and what the level of participation in the classroom discourse is. Equitable access to effective teaching and meaningful learning of mathematics is an engagement that, when sustained, enables the Nigerian senior secondary school students to successfully use their learning in the high-stakes assessments. This dimension, therefore, focus on conceptual understanding and equitable access to mathematical knowledge to a diverse number of students.

The fourth dimension is agency, ownership and identity, which refers to the opportunities the students get to explain or express their own ideas and the way they can build on those ideas. How are students being recognized as capable of learning mathematics and being able to contribute to the topic under discussion in the class? This dimension is also concerned with the opportunities students have to explain their own conceptual understanding and respond to each other's mathematical ideas in class through discourse and individual expression of such knowledge during the WAEC high-stakes mathematics

examinations. The willingness of the senior secondary school students to express mathematical knowledge and skills in the classroom and in high-stakes assessments makes teachers, the WAEC and other stakeholders in education identify them as active thinkers and learners.

The fifth dimension is the formative assessment, which is the evaluation that is done while the teaching and learning are in progress. It is how students' thinking is included in the classroom discussion, and whether mathematics instructional practices respond to students' ideas and help them to think more carefully. It is also the teachers' knowledge about each student's current mathematical thinking, and how he/she can build on it. Generally, it determines how effective the teachers' instructional practices are and the extent of students' learning progress or lack of it. The continuous assessment (CA) scores are derived from the formative assessments. Therefore, Schoenfeld's (2017a) TRU framework is concerned with teachers' effective instructional practices that embraced the five dimensions and it is positively related to students' emerging as knowledgeable, flexible and resourceful thinkers and problem solvers. These five dimensions of the powerful mathematics classroom proposed by Schoenfeld are focal points for mathematics teachers' instructional and assessment practices, gearing towards producing excellent performances by Kaduna State senior secondary school students in high-stakes assessments.

Schoenfeld (1992) is also one of the principal investigators of Balanced Assessment Project, which was sponsored by the National Science Foundation (NSF), aimed at describing the various components of mathematical understanding and performance to advise stakeholders responsible for constructing mathematics assessments at different levels of education, and to guide students and teachers in teaching/learning processes. In this project, a framework was created to determine method of evaluating students' performance in mathematics with an assessment system. The framework has seven dimensions: content; thinking processes; student products; mathematical point of view; diversity; circumstances of performance; and pedagogic-aesthetics. Schoenfeld's (2017a) five dimensions of powerful mathematics teachers' classroom instructional practices and his Balanced Assessment Project can both be linked to the Nigerian

mathematics curriculum, teachers' instructional and assessment practices, and high-stakes assessments in Kaduna State senior secondary schools. Therefore, it is highly likely that teachers of mathematics will adapt to these constituents of learning and mathematics instructional practices in high-stakes contexts. Figure 3.3 diagrammatically illustrates the five dimensions of the TRU of Mathematics framework, which can also be referred to as the five dimensions of powerful mathematics teachers' classroom instructional and assessment practices.

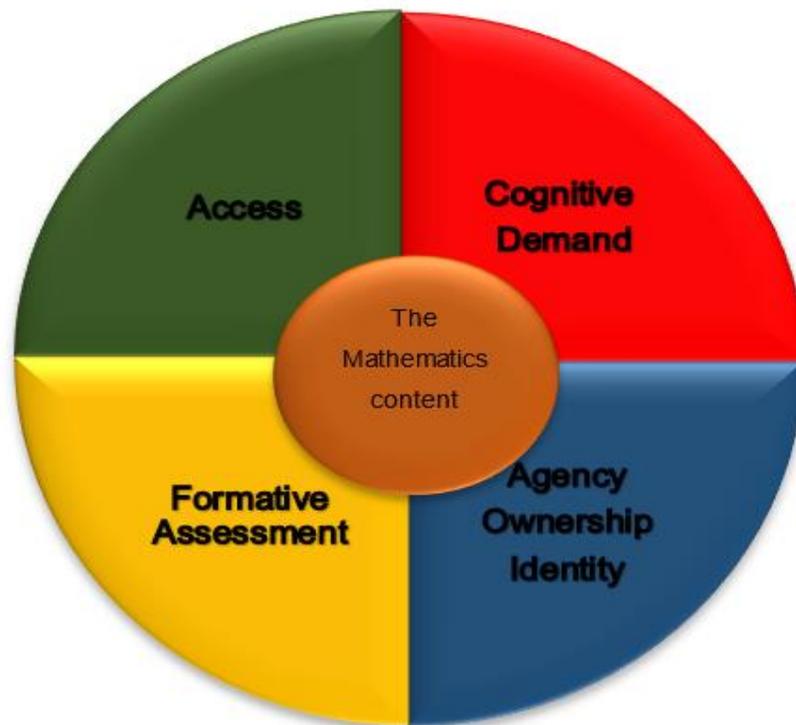


Figure 3.3: The five dimensions of the Teaching for Robust Understanding of Mathematics (TRUmath) Framework (Schoenfeld, 2010, p. 6)

Figure 3.3 diagrammatically presents the five dimensions of powerful mathematics teachers' classroom instructional and assessment practices. The diagram illustrates the individual dimensions and their interrelationships, but each dimension has its own integrity. The Mathematics content is in the centre because mathematics is the focus of classroom instructional and assessment practices, and the interaction between the teacher and students should be of a high quality for optimal performance in high-stakes assessments. The other four dimensions' focus on the students' engagement with the

mathematics, and their achievement derived from that engagement. Schoenfeld (2017a, b) asserts that when all the senior secondary school mathematics teachers teach and assess the students along these five dimensions, they will produce students who are powerful mathematical thinkers. The instructional materials, professional development and classroom observations will be most powerful if they are aligned with these five dimensions.

The students make sense of mathematics when they are engaged in mathematical tasks (Schoenfeld, 2016, 2017a) and the strategies that the students apply in problem situations; the mathematical representations that the students create; the arguments that the students make; and the conceptual understandings that the students demonstrate (Empson & Jacobs, 2008). This depends on the teachers' ability to listen, to observe, to prompt, and to make sense of the students' actions and comments in their instructional and assessment practices and in meeting with the demands of high-stakes assessments.

### **3.2.3 Bloom's taxonomy of educational objectives in mathematics classroom instruction/assessment and the high-stakes examinations**

Bloom's taxonomy of educational objectives is a framework showing what teachers expect or intend students to learn from their instructional practices (Krathwohl, 2002). In other words, it is a scheme used for classifying educational goals, objectives, and most recently, made educational standards to meet the global challenges in mathematics instructional and assessment practices. The framework was first conceived as a means of facilitating the exchange of test items among faculty at various universities in order to create question banks for classroom assessments practices and high-stakes assessments (Bloom et al., 1956; Krathwohl, 2002). The original taxonomy provided carefully developed definitions for each of the six major categories in the cognitive domain. The six major levels include: knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom et al., 1956; Krathwohl, 2002). Mathematics teachers are expected to use these levels of Bloom's taxonomy in stating their lessons instructional objectives and constructing their students' examination/assessment questions.

Smith et al. (1996) elaborate on the six categories of Bloom's taxonomy. They defined knowledge as recalling previously learned methods or ideas; the information stored by

students are later remember factual knowledge in an assessment. Comprehension is the ability to understand any learning task and being able to use some of the ideas. Application is the ability to transform learning into new or practical situations to solve problems. Analysis is the ability to compare ideas and draw conclusions. Synthesis is the ability to reconstruct previously learned experiences into new forms and the ability to harmonize unclear elements of many sources into a whole. Evaluation is the ability to justify ideas and make comparisons about the values of procedures for some purpose based on definite criteria.

Bloom's Taxonomy is a method of classifying mathematics examination questions at different levels of education. Smith et al. (1996) modified Bloom's taxonomy of educational objectives for it to be more relevant to mathematics education. They first used the taxonomy to classify undergraduate mathematics examination questions to show how an examination could be constructed to assess a broad range of knowledge in mathematics. Table 3.2 presents how Smith et al. (1996) categorized and modified Bloom's taxonomy into three groups.

Table 3. 2 Smith's Taxonomy (Smith et al., 1996).

GROUP A	GROUP B	GROUP C
Factual knowledge	Information transfer	Justifying and interpreting
Comprehension	Application in new situations	Implications, Conjectures and Comparisons
Routine use of procedures		Evaluation

Group A categories are: factual knowledge; comprehension and routine use of procedures. The factual knowledge entails recall of a formula, a definition or a proof. Questions in the comprehension test require students to express their understanding of the factual knowledge they have. In the routine use of procedures, students use algorithms or procedures that they have learned previously.

In group B the categories are information transfer and application in new situations. In the first part students transfer information from one representation to another – for example,

information from a graph into algebraic form. In the same category, questions demand students to be able to decide on a proper method or to explain or summarize information. Tasks focus on the choice and application of methods in new situations in the second category – for example, modelling or proving an unseen theorem using previously seen methods.

Smith et al. (1996) further explain that group C focuses on higher-order skills such as: justification and interpreting, implications, conjectures, comparisons and evaluation. To answer mathematics questions in the justifying and interpreting category, students should be able to justify their reasoning and choices. They should also be able to interpret their outcomes. It is imperative to know that problems in the implications, conjectures and comparisons category require students to be able to see the implications of a result and make further conjectures, and be able to compare methods. In the last category, which is evaluation, students should be able to make judgments based on definite criteria and be able to use their knowledge in creative ways. Smith et al. (1996) reviewed the taxonomy to make it more relevant to mathematics instructional and assessment practices and high-stakes assessments.

Krathwohl (2002) further categorized knowledge into four dimensions and reviewed Bloom's taxonomy by renaming the cognitive levels and changing them into verbs as remember, understand, apply, analyse, evaluate and create.

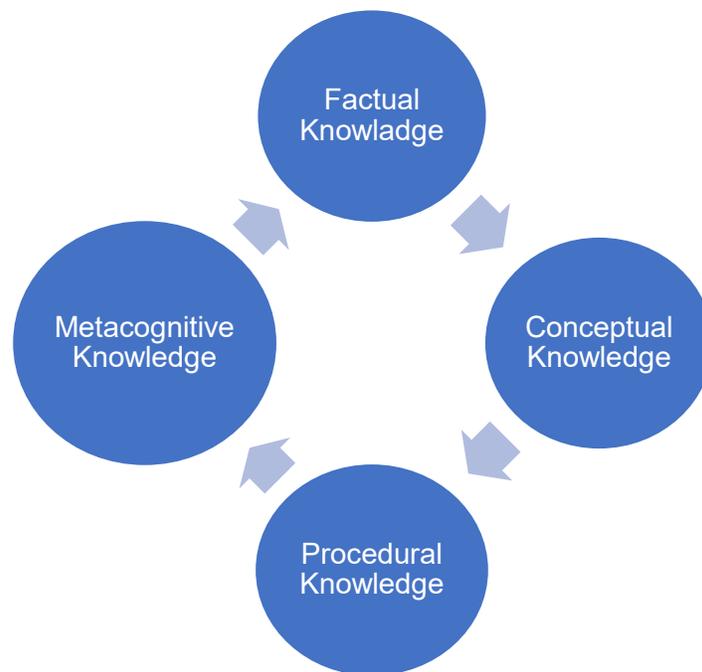


Figure 3.4 The four dimensions of Krathwohl's categories of knowledge

Figure 3.4 shows how Krathwohl (2002) categorized knowledge into four dimensions. The first category is factual knowledge which focuses on the basic elements that students must know and to be acquainted with a discipline or solve problems in it. The other factual knowledge are knowledge of terminology and knowledge of specific details and elements. The second category is conceptual Knowledge which is concerned with interrelationships among the basic elements within a larger structure that enables them to function together. Its subcategories are knowledge of classifications and categories, knowledge of principles and generalizations and knowledge of theories, models, and structures. The third category is procedural knowledge about how to do something, methods of inquiry, and criteria for using skills, algorithms, techniques and methods. Other subcategories are knowledge of subject-specific skills and algorithms, knowledge of subject-specific techniques and methods, and knowledge of criteria for determining when to use appropriate procedures. These categories explain how mathematics teachers can fully engage the students in their instructional and assessment practices. The fourth category is metacognitive knowledge, which focuses on knowledge of cognition in general, awareness and knowledge of one's own cognition. Its subcategories are strategic knowledge, knowledge about cognitive tasks, including appropriate contextual and

conditional knowledge and self-knowledge. These categories of knowledge dimension revolve around teachers' instructional and assessment practices and the item types of questions constructed for high-stakes assessments

The national policy of education (FRN, 2004) in Nigeria spells out the use of Bloom's taxonomy in constructing classroom tests and examinations; WAEC high-stakes examinations also used Bloom's taxonomy in setting examinations questions for the mathematics WASSCE considering the senior secondary school level of education. In test item construction, the mathematics teachers are expected to use a two-dimensional grid table called 'table of specification', 'test blueprint' or test matrix (Bosan, 2018). The vertical axis of the table should have the curriculum content covered with the students in the class (the content of record of work) and the horizontal axis indicates the level of cognitive process dimension. The intersections of the curriculum content covered, and cognitive process categories form the cells containing the number of questions to be asked from each topic and at each cognitive process level. The spread of the questions across the content and cognitive process levels is dealt with using percentages.

Krathwohl (2002) later modified the taxonomy use verbs to suit the mathematics instructional and assessment practices, and the high-stakes examination bodies. Hence, their implementation in WAEC's WASSCE (Schoenfeld, 2017a). The teaching for robust understanding framework was revised to help describe and construct balanced assessment instruments. It specifically deals with mathematics. The level of cognitive demand framework (Smith & Rothkopf, 1984) is much more focused on levels of procedural questions and that is why it is particularly useful to this study.

### **3.3 Conceptual framework on the effect of high-stakes assessments on mathematics teachers' instructional practices in Nigerian**

The conceptual framework gave theoretical overview of the study and the order within that process (Leshem & Trafford, 2007) and it is a model whereby researchers represent graphically the relationships between independent and dependent variables, and other related concepts in the study (Orton, 2004; Rudestam & Newton, 1992; Wekesa, 2010). A conceptual framework assists the researcher to quickly see the proposed interrelationships between the variables or constructs that underlie this study. Figure 3.4

below is the conceptual paradigm that explains the procedures in mathematics instructional and assessment practices with reference to Popham (2001, 2003; Schoenfeld, 1992, 2016, 2017a, 2017b; Bloom et al., 1956; Krathwohl, 2002). The mechanisms surrounded and linked to mathematics instructional and assessment practices are the national senior secondary school mathematics curriculum and the WAEC syllabus; teachers' knowledge, self-efficacy and beliefs; the learning facilities in the school system; and the interaction between the classroom assessments and the high-stakes assessments (the WASSCE) in senior secondary schools.

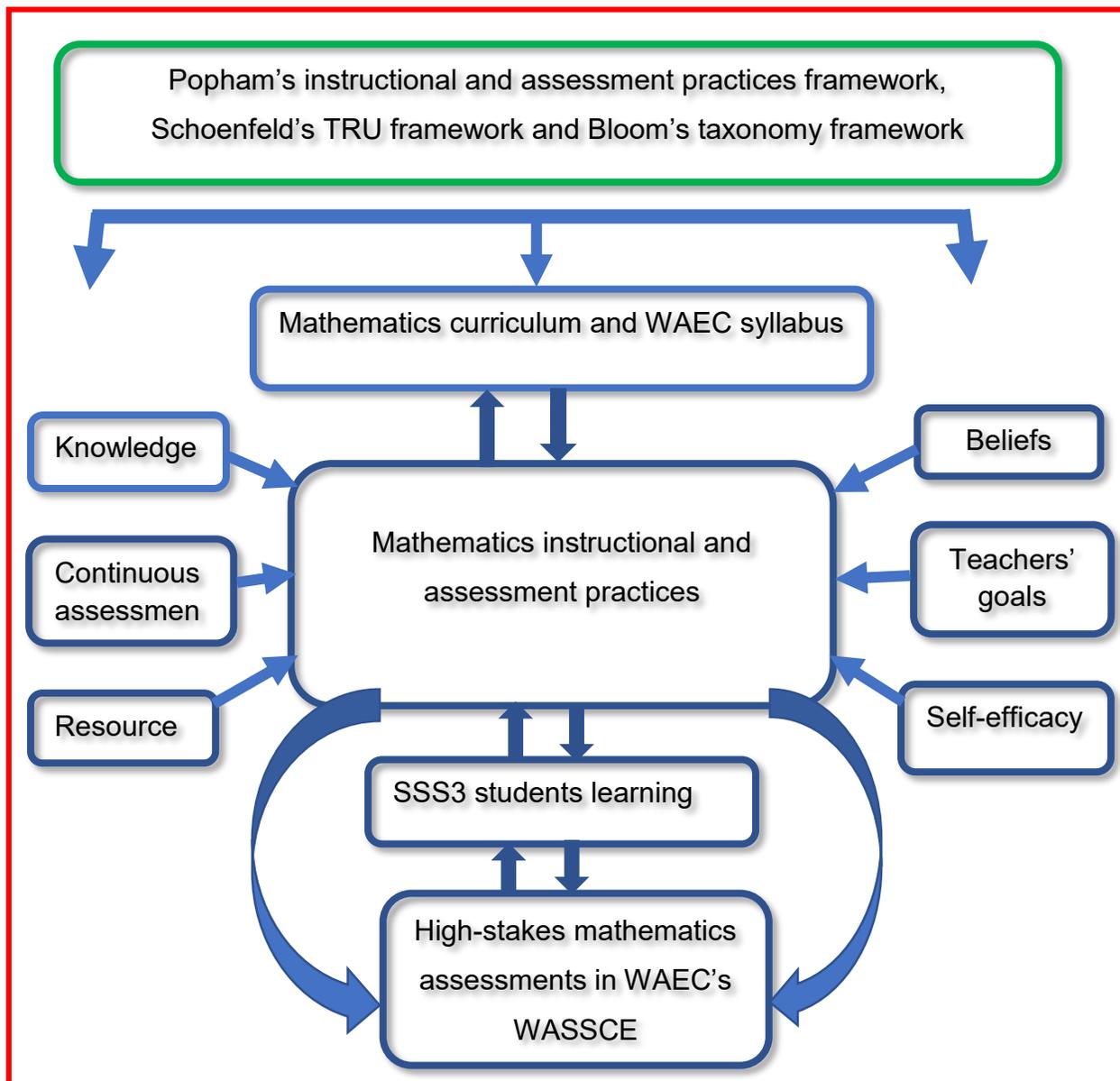


Figure 3.5: Conceptual framework of effect of high-stakes assessments on mathematics teachers' instructional and assessment practices

From Popham's (2001, 2003, 2004) framework, Schoenfeld's (1992, 2008, 2016, 2017a) framework and Bloom's (1956) taxonomy, the teachers use the mathematics curriculum content and the WAEC syllabus for their instructional practices. These theoretical frameworks give a coherent set of findings and provide an interpretive lens for the study (see section 3.5). From Figure 3.5, the mathematics teachers' knowledge, self-efficacy and beliefs are teacher variables that also affect instructional, and assessment practices. The teachers used mathematical knowledge for teaching (MKfT) and pedagogical content

knowledge (PCK) for effective mathematics instructional and assessment practices. The teachers' self-efficacy determines their level of confidence to present their lessons effectively in the mathematics classroom. Teachers' beliefs are the strongly held views that influence them to exhibit certain behaviours consciously or unconsciously in their instructional and assessment practices. As seen in the previous chapter 2 (see section 2.14), school-based assessments (SBA) form part of the total scores in mathematics WASSCE. The framework also shows that CA policy in Nigeria also affects mathematics teachers' instructional practices.

The resources – which are human (mathematics teachers) and non-human (instructional materials: manipulative models, games, computers, textbooks, charts, workbooks, instructional and curriculum guidelines) – make instruction easy, interesting and meaningful (Adetula, 2015). Mathematics teachers also use the learning resources (the school instructional materials) to facilitate meaningful learning of mathematics. In the mathematics teachers' instructional and assessment practices, mathematics knowledge is accessed and connected to the senior secondary school three students (SSS3 students). The conceptual understanding of the senior secondary students in mathematics will then reflect in their performance in the school's continuous assessments (CA) and the WAEC high-stakes mathematics examinations. The senior secondary schools CA scores and the WAEC's WASSCE scores in mathematics gives the teachers' feedback on students' level of knowledge and skills acquired in mathematics (their performance in mathematics). Therefore, for successful implementation of effective mathematics instructional and assessment practices for success in WAEC high-stakes mathematics examinations, teachers should follow these coherent procedures. It is important to note that the content is shown in the model leading to the feedback element. This implies that content helps define the boundary conditions within which the system operates by showing how the mathematics teachers exercise their power in the school system and the schools' relationship with WAEC high-stakes examinations.

Additionally, knowledge of content and effective teaching in mathematics is an important element in the mathematics teacher's effectiveness in the classroom. According to Koning, Blomeke, Paine, Schmidt and Hsieh (2011), knowledge of content and teaching

means the teacher is in charge of effective classroom instructional practices. They note four variables for effective instructional practices, namely: (1) Quality of instruction means activities of teaching that make sense to the students; (2) Appropriateness of the level of instruction means the teachers adapt instructional practices to cater for the needs of the students; (3) Incentives: the teacher should motivate the students to pay attention, to learn, and to perform the tasks assigned to them. Ideally, teachers need to relate topics to the students' learning experiences; (4) Time means the instructional and assessment practices enable the students to spend quality time on tasks.

These four variables are interconnected in the instructional processes. The success of mathematics teachers' instructional practices depend on the principles that guide the school system (Koning et al., 2011; Prediger, 2010). Also, the literature has revealed the importance of effective mathematics instructional practices in the secondary schools, yet quite often the research does not give definite answers, but it provides one with the tools to arrive at one's own conclusions (Mitchell, 2006). This study should reveal and give some answers on the effect of WAEC high-stakes assessments on mathematics teachers' instructional and assessment practices in the ten Kaduna State senior secondary schools.

### **3.4 Conclusion**

This study is underpinned primarily by Popham's (2001, 2003, 2004) instructional and assessment practices, Schoenfeld's (1992, 2008, 2017a) TRU framework and Bloom's taxonomy of educational objectives frameworks (Bloom et al., 1956; Krathwohl, 2002; Leshem & Trafford, 2007). These frameworks served as guide or interpretive lens for the study on how instructional, preparatory and assessment practices in Kaduna State senior secondary schools are influenced by high-stakes assessments. This chapter also discussed the conceptual framework that guided the study.

The next chapter discusses the research design and methodology for this study.

## CHAPTER 4

### RESEARCH METHODOLOGY

#### 4.1 Introduction

The purpose of this chapter is to explain the research design this study followed, and to justify the methods that were chosen to generate the data and data-analysis procedures used to achieve the objectives and answer the research questions that guided the study. This chapter thus discusses the qualitative ethnographic case study design, and the specific instruments that were used and their trustworthiness. Figure 4.1 shows the link between the methods, on the one hand, and the research aim, objectives and questions, on the other hand. Therefore, this qualitative ethnographic case study includes multiple methods of qualitative inquiry to explore the Kaduna State senior secondary school mathematics teachers' instructional practices in the preparation for the WAEC high-stakes examination.

#### 4.2 Research design

A research design is a plan of action that bridges the gap between research questions and the implementation of the research (Blanche & Durrheim, 2006). It is the blueprint that specifies and structures the action process of collection, analysis and interpretation data to address the study's research questions. In research, one may adopt an empirical or a non-empirical research design (Mouton & Schumacher, 2011). According to Mouton and Schumacher (2011), the data from empirical studies are generated from surveys, experiments, case studies, programme evaluations, ethnographic studies, amongst others. Non-empirical designs include conceptual analysis, theory building and literature reviews, among others. In short, empirical research is guided by data obtained from observation and systematic research methods rather than opinions or authorities (Mouton & Schumacher, 2011; McMillan & Schumacher, 2001). A research design caters for the purpose, the theoretical paradigm, the context and the research techniques used to gather and analyse data (Creswell, 2009; Mouton & Schumacher, 2011; Blanche & Durrheim, 2006). Therefore, this study undertook a qualitative ethnographic case study where the study incorporated ethnography and a case study. These are two empirical

forms of qualitative inquiry for an in-depth study of senior secondary school mathematics teachers on how high-stakes assessments influenced their instructional practices (Creswell, 2006; Wolcot, 1990).

Figure 4.1 gives an overview of the research design and methods including the research aim, objectives and questions used for this study.

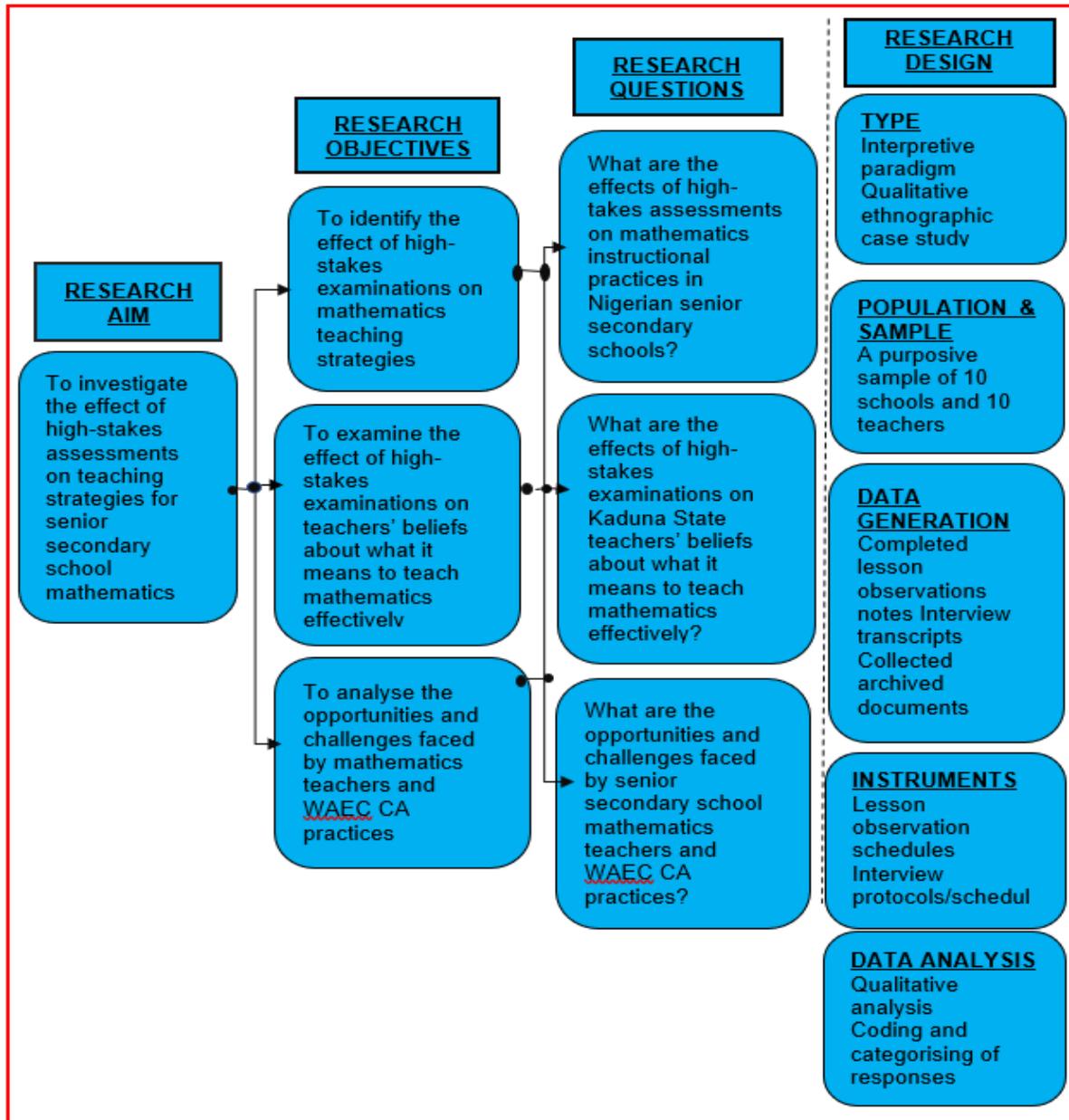


Figure 4.1 Research design and methodology for this study

Figure 4.1 shows the most important components of the research process of this empirical study. The figure depicts the aim, objectives and research questions of the study as a guide to focus on the design and methodology. The purpose of the current study is to gain an insight into the effects of WAEC high-stakes examinations on mathematics teachers' instructional, preparatory and assessment practices in Kaduna State senior secondary schools. The issues were approached through an ethnographic case study (Wieraman, 2000; Wolcot, 1990) and employed a qualitative approach to data collection, analysis and interpretation.

Patton (2002) contends that qualitative research designs are naturalistic to the degree that the research occurs in a real-world context. Patton further explains that in a qualitative inquiry the researcher sets out to understand the day-to-day reality of the participants and accepts the complexity of the changing nature of a programme – specifically, the complexity of the Kaduna State mathematics teachers' classroom instructional and assessment practices in preparation for WAEC high-stakes examinations was investigated in this study. The ethnographic approach provided the framework for studying meanings, patterns, expressions and mathematics instructional practices linked to frameworks by Popham (2001, 2003, 2004), Schoenfeld (1992; 2016, 2017a) and Bloom's (1956) taxonomy of educational objectives as revised by Smith et al. (1996) and Krathwohl (2002). The ethnographic case study also enables the researcher to understand the participants' daily experiences related to instructional and assessment practices in an evolving environment. Additionally, this case study was a systematic, detailed and in-depth investigation of the effects of the high-stakes assessments on mathematics instructional and assessment practices. The research paradigm, qualitative research, case study and ethnography are discussed in detail in sections 4.2.1, 4.2.2, 4.2.3 and 4.2.4, respectively.

#### **4.2.1 Qualitative research**

This study adopts a qualitative case study design (involving ten mathematics teachers) and applies ethnographic/qualitative approaches because a qualitative case study design investigates current situations in a real-world context (Yin, 2009). Accordingly, the current study illuminated the instructional and assessment practices in Kaduna State senior

secondary school mathematics teachers, which become evident through lesson observations, interviews and documentary analysis. Qualitative research is not intended to make generalisations but for to achieve a deeper view of the situation (Polit & Hungler, 1999; & Williams, 2007). However, this study can make generalisation about theory and practice as well as act as a framework for the preservice teacher. The preservice teachers will see and adapt these principles and put them into practice during their service years. The phenomenon of interest was the effects of WAEC high-stakes examination on mathematics teachers' instructional practices in Kaduna State senior secondary schools. Hammersley (2013) views qualitative research as investigation into a situation that places the emphasis on how a particular unit operates using oral rather than quantitative evidence.

Furthermore, Denzin and Lincoln (2011) contend that there are different ways in which qualitative research can be undertaken; it can be handled through case study, inquiry, participant observation, interviews, visual methods, interpretative analysis, among others. More so, qualitative research covers a range of interpretive techniques that can use descriptions, coding, translations and agreeing with the meaning of such interpretations in real-life situations (Merriam, 2009) such as the teachers' instructional and assessment practices. Wolcot (1994) categorises qualitative research into three types: analysis, description and interpretation. Saldaña (2011) elaborates on how description helps to build a basis for analysis and interpretation by supplying facts and figures. Analysis helps the researcher to generate the key facets of data and the interrelationships between them, but interpretation goes beyond the data towards a broader understanding. This procedure was followed closely as interpretation is framed within Popham's (2001, 2003, 2004), Schoenfeld's (1992, 2016, 2017a) and Bloom's taxonomy. The frameworks served as a lens for investigating mathematics teachers' effective instructional and assessment practices, sense making in mathematics and for understanding the optimal performances of senior secondary school students in WAEC's WASSCE.

Qualitative research relies on the collection of textual or non-numerical data, such as words, images and categories (Creswell, 2009; McMillan & Schumacher, 2001; Williams, 2007) Therefore, the qualitative data gathered became narrative accounts of the

instructional behaviours observed during Kaduna State senior secondary school mathematics teachers' lesson observations and interviews. In qualitative research the participant's viewpoint is the social phenomenon that is being researched (Williams, 2007). Additionally, qualitative research is a holistic approach that focuses on discovering and understanding the experiences, perspectives, thoughts, behaviour, views, experiences and emotions of the participants (Hiatt, 1986; Polit & Hungler, 1999; Williams, 2007). It utilises a natural approach that seek to comprehend the phenomenon in the content-specific setting, such as the real-world setting, where the researcher does not control the phenomenon of interest (Patton, 2002). The phenomenon of interest is how high-stakes assessments influence the mathematics teachers' instructional and assessment practices in Kaduna State senior secondary schools, Nigeria.

Different literature sources point to the strengths of qualitative research. Firstly, it is useful to describe complex phenomena (Creswell, 2014; Johnson & Onwuegbuzie, 2004). Secondly, it provides the participants' viewpoints, personal experiences of the phenomena or the context (Creswell, 2014; Johnson & Onwuegbuzie, 2004) and not those of the researcher (Creswell, 2014). Thirdly, it can determine how participants interpret concepts, and the data are usually collected in natural settings (Johnson & Onwuegbuzie, 2004). Information obtained from the ten mathematics teachers' lesson observations were from a natural setting. Fourthly, it focuses on people's narrative accounts that can be examined within the original context in which observations occur (Castro, Kellison, Boyd, & Kopak, 2010) (Creswell, 2014). Fifthly, it has the capacity for generating richly detailed accounts of human experiences (Castro, Kellison, Boyd, & Kopak, 2010; Divan, Ludwig, Matthews, Motley, & Tomljenovic-Berube, 2017). Information obtained from mathematics teachers' interviews and reflection journals (the field notes, video-recordings and photographs) were transcribed, coded and used for conceptual analysis. These reasons were applicable to the field work that was done by the researcher.

However, Creswell (2014) and Johnson and Onwuegbuzie (2004) point out the following weaknesses of qualitative research or data: (1) It is difficult to test hypotheses and theories with qualitative research; (2) The researcher can be biased and that can easily

influence results; (3) It is time-consuming to collect and analyse qualitative data – the lesson observations and interviews have to be transcribed and coded verbatim; (4) It only investigates a limited number of sample sizes and therefore has limited generalisability; and (5) It is highly subjective. Bryman (2012) adds that qualitative research can be difficult to replicate, and there is a lack of transparency in the methods used and how conclusions are drawn. Despite the weaknesses of qualitative research, the researcher still opted for this approach to be part of the study's research design because the strengths outweigh the weaknesses.

#### **4.2.2 Research paradigm**

There are three generic orientations that influence how researchers understand and view the world: ontology, epistemology and methodology (Denzin & Lincoln, 2011; Gray, 2018; Morgan, 2007). These three generic orientations collectively account for the research paradigm (Denzin & Lincoln, 2011). These paradigms guide the planning, implementation, analysis and interpretation process in research (Guba & Lincoln, 1994; Blanche & Durrheim, 2006). In the context of the orientations Denzin and Lincoln (2011) view a paradigm as a net that contains the researcher's epistemological, ontological and methodological premises, while Morgan (2007) defines it as the consensual set of beliefs and practices that guides a field of study. In other words, a paradigm is a set of beliefs that guide action. The paradigm of any research serves as a lens to view and interpret the data collected from the fieldwork. It is a viewpoint of research based on shared assumptions, concepts, values and practices (Johnson & Christensen, 2004; Poni, 2014).

The types of paradigm in education, social and behavioural science include: positivist, interpretive, constructionist, post-structural/post-modern and pragmatic paradigms (Carr & Kemmis, 1986; Merriam, 1998; Waghid, 2002; Henning, Van Rensburg & Smit, 2004) and each has its own strengths and weaknesses. This study falls within the interpretive paradigm because it is a qualitative ethnographic case study research design. It was deemed appropriate for achieving the purpose of this research, because it assisted the researcher to understand the participating teachers' in their instructional, preparation and assessment practices. In a qualitative interpretive paradigm (Creswell, Shope, Clark & Green, 2006) there are several research methodologies, each with its own underlying

philosophies, practices and modes of interpretation. Creswell (2009) identifies five research methodologies, namely case study, ethnography, grounded theory, narrative research and phenomenology. The interpretive paradigm in this study focused on understanding of internal reality, subjective experiences through qualitative, observations, interviews and documents analysis. This is done in response to the demands and pressures of the WAEC high-stakes examinations in the gateway subject of mathematics in Kaduna State senior secondary schools, Nigeria.

This qualitative ethnographic case of a classroom culture was guided by the interpretive paradigm into which several qualitative methods, ethnography and case study were incorporated in order to better understand the culture (Denzin & Lincoln, 2011; Morgan, 2007). This paradigm allows the researcher to interpret using a myriad of methods to understand a culture through the lens of the subjectivity and experiences of the participants. The cultural features like the schools/classrooms visited by the researcher, the schools activities and the teachers' instructional and assessment practices were observed in their natural settings. The interpretive paradigm focuses on understanding the meaning of the phenomena and human activities, and tries to understand individuals (Wang & Zhu, 2016). The role of the researcher in the interpretive paradigm is to understand, explain and demystify social reality through the eyes of different participants (Cohen, Manion & Morrison, 2007). This paradigm is therefore subjective and involves inductive reasoning. McMillan and Schumacher (2001) observe that every research effort involves a logical reasoning process using either deductive or inductive reasoning. Deductive reasoning is primarily employed in quantitative research and inductive reasoning applied in qualitative research (Creswell, 2009; Harwell, 2011; McMillan & Schumacher, 2001). In this inductive model of thinking the researcher in this study collected detailed information from ten Kaduna State senior secondary school mathematics teachers through lesson observations and interviews, and then categorized this information into themes, a process also called coding.

#### **4.2.3 Case study design**

This study is designed as a case study. A case study is an accepted approach for conducting research in a number of disciplines which provide in-depth descriptions of a

social phenomenon such as an individual, group, institution or community (Ary, Jacobs, & Sorensen, 2006; Omobude, 2014; Rousseau, 2015). Yin (2014) refers to case study as a method of research that allows the researcher to conduct an in-depth study within the context of real life. Yin (2014) claimed that a case study is both scientific and humanistic in nature, where the researcher addresses exploratory research questions to generate data. This is to incorporate an intensive analysis of an individual unit, stressing developmental factors in relation to the environment through multiple sources of information such as interviews, observations and official documents from schools (Rule & John, 2011). These definitions provide details about characteristics relating to the current study. The definitions express that a case study focuses on the individual unit (the participating teachers), intensive or in-depth analysis (detail, richness, completeness and variance), stresses developmental factors (a string of lesson observation and interviews over time) and relation to environment (relating to mathematics teachers' instructional and assessment practices in senior secondary schools).

Yin (2009) states three conditions for applying a case study design. Firstly, a case study has to focus on contemporary events (Benbasat, Goldstein, & Mead, 1987; Schell, 1992; Yin, 2009). The contemporary phenomenon in this study show how mathematics teachers' instructional and assessment practices are influenced by high-stakes assessments. Secondly, case studies are considered the best design where the researcher has no or little control over events and subjects (Benbasat et al., 1987; Schell, 1992; Yin, 2009). In this study the researcher had no control over the ten senior secondary schools and the participants' during the fieldwork. Thirdly, in this type of research questions or sub-questions will guide the researcher into the case study (Yin, 2009). Yin further categorised case studies into three types: exploratory, explanatory and descriptive in relation to the W's. Research questions and sub-questions with types of "what" questions are exploratory; types of "who" and "where" questions are descriptive; and "how" and "why" questions are explanatory. The research questions for this study focused mainly on "what" questions, as the researcher opted for an exploratory case study.

It is important to note that case studies are flexible and can generate a range of data. They can support all the different types of philosophical paradigms (Darke, Shanks, &

Broadbent, 1998; Lacono, Brown, & Holtham, 2011). However, on the one hand, an ethnographic study (see section 4.2.4) of this kind requires the researcher to be involved with the participants in their cultural environment (the ten Kaduna State senior secondary schools), while on the other hand, a case study has the advantage that it can focus on one case (a particular senior secondary schools' environment such as Kaduna State). Therefore, the purpose of this ethnographic case study is to understand the complexity of a single case, that is, how mathematics teachers' instructional, preparatory and assessment practices are influenced by WAEC high-stakes examinations in some Kaduna State senior secondary schools.

This study was conducted in ten Kaduna State senior secondary schools in Nigeria. The participation was voluntary (see the detail discussion of population and sampling in section 4.3). The case studied was the observed influence of high-stakes assessments have on mathematics teachers' instructional and assessment practices. The main research question required an in-depth understanding of the effects of high-stakes assessments such as WAEC's WASSCE on teachers' instructional practices in an educational context (the senior secondary schools) in which the participants were engaged.

#### **4.2.4 Ethnography (micro-ethnography)**

An ethnographic approach was suitable for this qualitative case study design because it sought to gather in-depth information of the social world of the participants, hangout, observe and record every activity of the participants (Dawson, 2009; Denzin & Lincoln, 2011; Hesse-Biber & Leavy, 2011; Peters, 2016). Information was sought from the senior secondary school mathematics teachers' instructional, preparatory and assessment practices, as well as their pedagogical beliefs, opportunities and challenges that they faced in continuous assessment practices in the school system and WAEC high-stakes examinations. Wieraman (2000) defines ethnography as a process of investigating and analysing local people's points of view, beliefs and practices of a phenomenon. In this instance, this study aims at describing and analysing instructional practices and the beliefs of mathematics teachers in relation to the effects that WAEC high-stakes examinations have on such practices and beliefs.

An ethnographic study is an in-depth opportunity to study a culture-sharing group in a natural settings, such as the whole school and/or group of classes (Creswell, 2006). Ethnography was important for this study because the data were collected from events (lesson observations and interviews) that took place within the context of the natural settings. The senior secondary school classrooms were the natural settings and the teachers' interactions with the students were those of the mathematics classroom culture. Thirty lesson observations, ten teachers' interviews and official documents contributed to the understanding of how instructional, preparatory and assessment practices were influenced by WAEC high-stakes examinations. This was how the study was structured to investigate the effect on the culture in response to the West African Senior School Certificate Examinations (WASSCE).

However, the use of ethnography in research such as this study has some limitations such as time-consuming observations, difficulty with note taking and report writing. The researcher decided to use the ethnographic approach in this study because of the inherent advantages: (1) It enabled the researcher to capture the mathematics teachers' instructional practices within different contexts; (2) It enabled the researcher to identify any inconsistencies between what the participants say and their classroom practices (i.e. an overview of principles and practice); (3) It provided the researcher with a rich source and variety of visual, verbal and documented data; (4) It provided the researcher with extensive and in-depth findings about the participants; and (5) It enabled the researcher to explore and develop new lines of inquiry, since ethnography relies on observation rather than some predetermined tests.

A typical ethnographic study employs different qualitative methods of data collection such as interviews, observation, field notes and document analysis for an extended period of time (Bryman, 2012; Fine, 2003; Omobude, 2014). Wolcott (1990) contends that it is possible to carry out a micro-ethnographic study which will focus on a shorter period of time, such as a couple of weeks to a few months. This study focused on micro-ethnographic investigation of three months' duration (November 2017 to January 2018) in ten selected secondary school mathematics classrooms in Kaduna State of Nigeria, where the researcher was part of the daily school life of the participants.

In line with Marshall and Rossman (2015), this micro-ethnographic case study was done in a naturalistic setting (the selected senior secondary schools); it drew from multiple methods that respected the humanity of the participants; it focused on context and was fundamentally interpretative. The literature convinced the researcher that ethnographic methods will lead to understanding the reality from the participants' perspectives (Genzok, 2003; Howard, 1995; Kaiser, 2002; Mills & Morton, 2013; O'Reilly, 2009). The researcher combined detail lesson observations over time with in-depth interviews of mathematics teachers and examined a collection of archived documents relating to the study to gather data. The researcher also involved himself in video recordings, photography and keeping field notes of their instructional and assessment practices as personal reflective journals. The essence was to get a holistic picture of the daily activities of participants in the Kaduna State senior secondary schools in their natural settings.

The main features of ethnography according to Holloway (1997, p. 10) are: (1) the collection of data from observation and interview; (2) thick description and the naturalistic stance; (3) work with the key stakeholders; and (4) the emic/etic dimensions. The researcher as a participant observer and an ethnographer was able to collect data from the ten Kaduna State senior secondary schools. More so, ethnography and participant observations are sometimes synonymous with respect to data in which the researcher remains in the social setting observing and listening to collect information from the culture of the group (Bryman, 2012).

### **4.3 Population and sampling**

The study population is the large group of elements or cases, whether individuals, objects, or events, that conform to specific criteria from which a sample is collected and in which data are generated in research (Graziano, 2000; McMillan & Schumacher, 2001, 2006). The population for this study was the senior secondary school mathematics teachers teaching senior secondary school three (SSS3) (see section 1.7) of Kaduna State, Nigeria. There are 314 public senior secondary schools in the state. The researcher did not investigate the private senior secondary schools, because they are profit-making institutions which were not likely to give him trustworthy and dependable results. Those private schools are run by proprietors to maximize profit. (Merriam, 2002) states that the

group of participants in a qualitative case study is usually small, non-random and purposeful. The researcher chooses the sample that serves the purpose of the research and for convenience. A sample is a subset of the population that is taken to be representative of the entire population (Babbie, Mouton, Voster & Prozesky, 2009; McMillan & Schumacher, 2006). An important word in this definition is 'representative'. A sample that is not representative of the population, regardless of its size, is inadequate for research purposes, as the results cannot then be generalized to the entire population under study, but can be generalised in the field of theory and practice of education.

The researcher purposively selected ten senior secondary schools and one mathematics teacher from each of the sampled senior secondary schools. Purposive sampling is a series of strategic choices about whom, where and how one does one's research (Palys, 2008). In this case, the purposive sampling technique used was based on characteristics of a population and the objectives of the study. Teddlie and Yu (2007) further characterise purposive sampling techniques as non-probability, purposeful or qualitative sampling. Non-probability sampling is a sampling technique whereby the samples are collected in a process that does not give all the individuals in the population equal chances of being selected. Purposeful sampling is, therefore, a non-probability technique used in qualitative research to identify and select information-rich cases for the most effective use of limited resources (Patton, 2002). A technique that target a specific type of individuals (i.e. the ten Kaduna State senior secondary school mathematics teachers) that provided a narrative account of information for the study.

Teddlie and Yu (2007) identify the following categories of purposive sampling techniques: (1) Sampling to achieve representativeness, or comparability: This technique is used when the researcher wants to (a) select a purposive sample that represents a broader group of cases as closely as possible or (b) set up comparisons among different types of cases; (2) Sequential sampling: This sampling technique uses the gradual selection principle of sampling when (a) the goal of the research project is the generation of theory (or broadly defined themes) or (b) the sample evolves on its own accord as data are being collected. This study chose the purposive sampling technique to achieve representativeness of a case study.

Participants in this study were selected in accordance with the following criteria: (1) They were mathematics teachers of the schools that were selected, and the schools identified were established as Kaduna State (Nigeria) senior secondary schools; (2) They were willing to reveal their true instructional and assessment practices for WAEC high-stakes assessments; (3) They were willing to share their experiences, views and beliefs about what it means to teach mathematics effectively and to explain the opportunities and challenges they faced as secondary school mathematics teachers faced with task of preparing students for the WAEC high-stakes examinations body in their continuous assessment (CA) practices.

#### 4.4 Research methods and data-collection instruments

Data collection is a series of activities aimed at collecting information to address research questions (Creswell, 2014; McMillan & Schumacher, 2006). The instruments used for this micro-ethnographic case study included lesson observations, teachers' interviews and documents (for detail discussion see 4.4.1, 4.4.2 and 4.4.3). The researcher used lesson observation schedules, semi-structured interview protocols for mathematics teachers (instructional, preparatory and assessment practices for high-stakes assessments) and documents analysis protocols for archived documents (senior secondary school mathematics curriculum, the WAEC syllabus, Chief Examiners Reports and sample of question papers). Figure 4.2 gives a summary of the instruments used in this study.

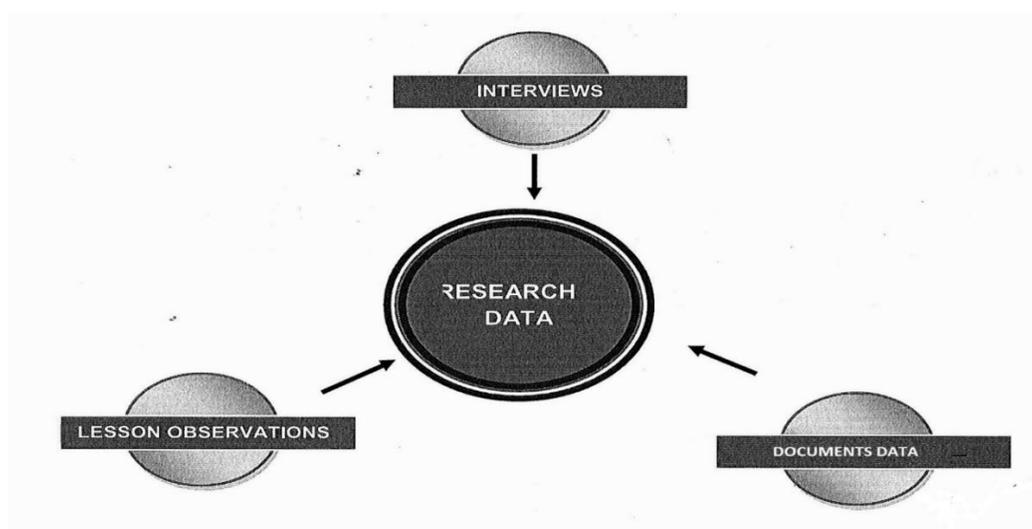


Figure 4. 2 Sources and generation of research data

As shown in Figure 4.2, a combination of completed transcribed interviews, the notes that were taken during classroom observations and the archived documents from the selected Kaduna State senior secondary schools were used in order to effectively address the research questions for this study. Field notes and video-recordings and photography were used during the lesson observations in the classroom and any other important facilities to be observed. The video-recording and photography were used only for transcription and as backup during analysis.

The researcher chose an ethnographic approach because it provided sufficient flexibility for describing, interpreting, exploring and explaining the process and products of mathematics teachers' instructional practices (Peters, 2016). Hence, these instruments and their importance to the study are discussed below.

#### **4.4.1 Lesson observations and observation schedule**

Observation is a method in which the researcher uses specifically formulated procedures for watching and documenting behaviour (Bryman, 2012; Driscoll, 2011; Johnson & Christensen, 2004; Le Grange, 2001) In other words, observation in this context is the process of watching teachers' and students' classroom interactions during mathematics instruction. Some of the literature defines observation as the systematic description of events and/or behaviours using the five senses to provide a written account of the situation under study (De Munck & Sobo, 1998; Marshall & Rossman, 2015). The researcher used some of his senses to watch the Kaduna State senior secondary school teachers in their mathematics instructional and assessment practices. From a data-collection perspective, Kawulich (2005) similarly describes observation as a way of collecting data by means of watching behaviour and events, or of noting physical characteristics in their natural setting. This method of data collection gave detailed, clear and concise data on how high-stakes assessments affect mathematics teachers' instructional practices in the ten Kaduna State senior secondary schools studied.

There are two types of observations: participant and non-participant observation (DeWalt & DeWalt, 2011; Hammersley, 2013). Participant observation is the process whereby the researcher watches the activities of the people under study in their natural setting

(Dawson, 2009; DeWalt & DeWalt, 2011; Kawulich, 2005). The researcher participated in activities of the group, adopted the way of life of the observed group and studies their behaviour or other activities not as an outsider but by becoming a member of that group. Non-participant observation means watching the activities of the group without participating in the group activities (DeWalt & DeWalt, 2011). Here the researcher does not try to influence them or take part in the group activities. The researcher opted for participant observation because non-participant observation is difficult. One cannot penetrate into the heart of a matter without proper participation in it.

Kawulich (2005) outlines five purposes for using participant observation in research: (1) It makes it possible to collect different types of data. Being on-site over a period of time familiarises researchers with the community, thereby facilitating their involvement in sensitive activities to which they generally would not be invited; (2) It reduces the incidence of reactivity, or of people acting in a certain way when they are aware of being observed; (3) It helps the researcher to develop questions that make sense in the native language, or which are culturally relevant; (4) It gives the researcher a better understanding of what is happening in the culture of the subjects, and it lends credence to one's interpretations of the observation. Participant observation also enables the researcher to collect qualitative data through surveys and interviews; (5) It is sometimes the only way to collect the right data for one's study. In this study, the researcher used participant observations for the advantages that it provides.

Kawulich, 2005) and Waxman (1995) point out that lesson observations are used by researchers: (1) to investigate the current status of instructional practices and identifying instructional problems; (2) to check for the verbal and non-verbal expression of feelings and beliefs of teachers in their instructional practices; (3) to determine how participants interact and communicate with the students; and (4) to check on how much time is spent on various activities. The use of observation in research increases the trustworthiness, and may help with familiarisation with the context and the phenomenon under study. Participant observation was also used to investigate how instructional, preparatory and assessment practices are influenced by high-stakes assessments in Kaduna State senior secondary schools, Nigeria.

McMillan and Schumacher (2006) also posit the following as some of the limitations of lesson observations: it is costly, time-consuming, susceptible to observer bias and is usually not anonymous but obtrusive. Observer effects may occur because teachers and students are aware that their behaviours are being observed. Therefore, a researcher is supposed to guide against the Hawthorne effect in the research. The Hawthorne effect is the influence that arises when research participants are aware that they are being studied, or when participants modify some aspects of their behaviour in response to their awareness of being observed (McCambridge, Witton, & Elbourne, 2014). There could be modifications of teacher or student behaviours.

However, McMillan and Schumacher (2006) point out some of the main strengths of using lesson observation. Observations capture natural behaviours, adhere to socially acceptable responses and are relatively unobtrusive. Observations (1) permit researchers to study the processes of education in naturalistic settings; (2) provide more detailed and precise evidence than other data sources; and (3) stimulate change and verify that the change occurred. The descriptions of instructional practices that are provided by lesson observations have also been found to lead to improved understanding and better models for improving teaching. Therefore, the strengths outweigh the limitations of observation. The technique was appropriate to investigate the effect of high-stakes assessments on mathematics instructional, preparatory and assessment practices of Kaduna State senior secondary school teachers.

An observation schedule was used to collect data about the extent to which the high-stakes WAEC mathematics assessments affect mathematics instructional and assessment practices, teachers' beliefs about what it means to teach mathematics effectively, and to identify the opportunities and challenges faced by teachers. The trustworthiness of observation is greater when the researcher uses lesson observation together with additional strategies, such as interviewing and document analysis (see Appendix D).

The researcher spent quality time with the participating teachers, where he was allowed to observe the teachers without any constraints. The pilot study was done in October 2017 (lasting one month) and the lesson observations were conducted between

November 2017 and January 2018 (three months). According to the academic calendar of Kaduna State Ministry of Science, Technology and Education, the first term runs from September to December, the second term from January to April, and third term is from May to August. The researcher had the chance to observe the participants either on a number of rotational visits or on consecutive days. He would have opted to make the lesson observations on consecutive days to see the connection between one lesson and another. The participants were teaching SSS3 and either SSSI or SSS2, because of a shortage of staff, and they were not teaching mathematics every day. More so, there was no guaranty of getting consecutive days without the interference of unforeseen circumstances like some school activities or the other. The lesson observations were therefore done on rotational basis to enable the researcher to at least observe the participants on equal number of visits (see section 1.4.7 and 5.4).

The researcher's role inside the class, throughout the three months of the study, developed from being one of passive observer to one of being an active participating observer. The researcher kept to the Chesterfield (1997) principles of good observation by remaining sensitive, considerate and helpful whenever possible; by recognising the teacher as the expert in respect of what was taking place in the class; by interacting with the entire population of people of interest.

The observations were systematised by means of an observation schedule (Appendix D), which facilitated the recording of, and the focusing on, the mathematics teachers' instructional and assessment practices, the teachers' beliefs about what it means to teach mathematics effectively, and opportunities and challenges faced by teachers and WAEC high-stakes examination in CA practices. Observer bias was minimised by the nature of the issues observed, which the observer recorded, as guided by the observation schedule.

#### **4.4.2 Reflection journal as data-collection method**

The reflection journal for lesson observation and interviews was a collection of field notes, video-recordings and photography (see Appendix D).

## Field notes

Field notes are very important aspect of ethnographic approach to research. Therefore, ethnographers should learn how to take useful and reliable notes regarding the details of their research (Omobude, 2014). One becomes more and more experienced in note taking and observation over time. The researcher adopted three styles of field notes as distinguished by Mckernan (1996, p. 94). They include (1) observational field notes that focus on events experienced through direct listening and watching in the school setting to accurate in description, and are meant to be accurate descriptions; (2) conceptual field notes that focus on self-conscious attempts to glean meaning from observations by looking at the facts and then to construct a personal statement of their importance and significance; and (3) procedural field notes that describe procedures, methods and operations focusing on notes on the research process itself or on the researcher's work. The three styles were adopted by the researcher in order to gain an in-depth knowledge of the participants' interactions within the school setting.

Furthermore, every field researcher adopts various techniques of writing field notes. This is mainly according to whatever strategy works best for the individual. For example, one researcher may use brackets to indicate personal feelings and reflections on bits of data, while another field researcher may use the "comments" function colour to differentiate observations from reflections. Others might create two columns for their full field notes - one containing notes only about what was observed directly and the other encompassing reactions and impressions. The data collected were in form of lesson observations and interviews transcripts and (Saldana, 2009) a dramaturgical coding system (see section 4.6).

It may therefore be tempting to conclude that there is no absolutely right or wrong way of writing field notes. Chiseri-Strater and Sunstein (1997) contend that the important message is that the researcher should adopt a technique that allows him/her to write accurately, in as much detail as possible and be able to differentiate between observations and reflections. Chiseri-Strater and Sunstein (1997, p. 11) further developed a list of what should be included in all field notes: (1) Date, time, and place of observation; (2) Specific facts, numbers, details of what happens at the site; (3) Sensory impressions:

sights, sounds, textures, smells, taste; (4) Personal responses to the fact of recording field notes; (5) Specific words, phrases, summaries of conversations, and insider language; (6) Questions about people or behaviours at the site for future investigation; and (7) Page numbers to help keep observations in order (see Appendix G). However, all field notes are generally made up of two parts: the descriptive information and the reflective information. In descriptive information the researcher tries to precisely document the factual data like date and time as well as actions, behaviours, and conversations. In the reflective information the researcher tries to write notes about the observed incidents and interviewee's thoughts, ideas, questions, the verbal and non-verbal behaviours (Wilkerson, 2002). In this study reflective information dealt with the effect of high-stakes assessments on mathematics instructional, preparatory and assessment practices of teachers from ten Kaduna State senior secondary schools.

Chiseri-Strater and Sunstein (1997) further recommend that field notes should be written as soon as possible after an observation is complete, because the initial notes may be ambiguous and, unless such notes are reconsidered as quickly as possible after the observation, vital details that may assist in the full interpretation of the data may be lost. Therefore, immediately upon leaving any observation site in the field, the researcher in this study took time to complete the brief notes. Even if one feels that the notes one has taken in the field are complete, one may be very surprised by how much more one will be able to remember once one sits down without disturbance and reads through what one has jotted down. One can add one's own reflections or observations when one writes up notes that are more complete. One could even say that one's field notes can never contain too much detail, because writing as much as possible may help in avoiding hasty generalizations in one's field notes. In addition, it may be helpful to have some documentation of one's first impressions and of the kinds of details that later become so much a part of the everyday session.

### **Video-recordings and photography**

In addition to methods that generated textual data, videos and photographic media were used to capture the details of the natural settings and activities during the research. Altrichter, Posch and Somekh (1993) indicate that video-recordings make the context and

causal relationships more accessible and behavioural patterns more visible. Patton (2002) indicates that videos can highlight significant facts if the researcher has skills that go beyond pressing the record button (Patton, 2002). Using video-recording together with other observation instruments in this study sounded like an excellent idea to assist the researcher to gain a more comprehensive picture of what transpires in mathematics classrooms instructional and assessment practices. Reasons for using video-recordings to research classroom activities is that a videotape can preserve more aspects of interaction including talking, gestures, eye gaze, manipulations and computer displays (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Video-recording enables one to capture phenomena that one might otherwise miss and can allow the researcher to interpret data in fine-grained detail during analysis (Schoenfeld, 2016, 2017b). In this study some research lessons were video-recorded and photographed. However, these data were used only for transcriptions.

#### **4.4.3 Interviews**

Gillis and Jackson (2002, p. 466) define an interview as a “face-to-face” verbal interaction between the researcher and the participants in which the researcher attempts to elicit information from the respondents, usually through direct questioning. According to Frey and Oishi (1995), an interview is a purposeful conversation in which one person asks prepared questions (interviewer) and another answers them (interviewee/respondent). Although this does not fit all circumstances, the interview is a very useful means of inquiry and for getting the story behind a participant’s experiences.

Interviews take the form of face-to-face or telephone questioning, usually structured, semi-structured or unstructured questioning, which provides the researcher with a clear picture of the thinking processes and intentions whilst respondents present them to the researcher via words (Barbie & Mouton, 2009; Creswell, 2014; Dawson, 2009; Kajornboon, 2005; Kendall, 2008; McMillan & Schumacher, 2006). This study collected data using semi-structured interviews in order to explore the effect of high-stakes WAEC mathematics assessments on a sample of the Kaduna State senior secondary school mathematics teachers’ instructional, preparatory and assessment practices as well as

their beliefs and challenges about these practices. The semi-structured interviews were most beneficial because they probed respondents' or participants' point of view.

Schensul, Margaret, LeCompte, Bonnie and Nastasi (1999) contend that semi-structured interviews combine the flexibility of unstructured, open-ended interviews with directionality and an agenda to produce focused, qualitative, textual data. The researcher selected in-depth face-to-face interviews because of the advantages of the social and gestural cues. Opdenakker (2006) adds that the benefit of social cues, such as voice, intonation, body language, amongst others, of the participant during the interview can give extra non-verbal information regarding the participant's response to a certain question. Another advantage of semi-structure interviews is that the interviewer can immediately react to the interviewee reactions or responses to seek more information or clarification. The responses of participants are also more spontaneous, without an extended reflection (Opdenakker, 2006). The participants, therefore, react immediately to the question and the response becomes more spontaneous or naturalistic.

Semi-structured interviews are non-standardised and are frequently used in qualitative analysis and the interviewer does not conduct the interview to test a specific hypothesis (David & Sutton, 2004). The researcher has a list of key themes, issues and questions to be covered. In this type of interview the order of the questions can be changed depending on the direction of the interview. An interview schedule (see Appendix E) was also used, but additional questions can be asked. Kajornboon (2005) indicates that semi-structured interviews are more of an open-ended nature and lend themselves to probing participants' views about the subject matter. Kajornboon (2005) points out that if the respondent is uncertain about the question, the researcher can explain or rephrase the question. The researcher used these tactics during interviews to make the participants tell him how they were influenced in their instructional practices by the high-stakes assessments.

Researchers in mathematics education ask questions, get answers and then engage in attempts to analyse these answers. In looking at how to get access to the participants, two questions arise (Bryman, 2012). Bryman observed that the first question the researcher should ask himself/herself is how he/she will establish a link with the anticipated participants. Secondly, the researcher must also consider if the anticipated

participants can provide the desired response with a view to achieving the overall aim of the study.

After identifying the participants to work with, what to ask them and how to access them, the researcher may again be confronted with the issue of the technique that should be adopted to elicit the best and most objective answers from the participants (Dawson, 2009). As a basic way of addressing this question, Schoenfeld et al (2008) and Wood, (2006) suggest that the researcher should check for contradictions, imbalance, exaggerations or inconsistencies on the part of the interviewees. While asking for explanations, it is very important that the researcher requests the opinions of the respondents. Wood (2006) adds that the researcher should try as much as possible to be a good and active listener, thereby showing the participant that great attention is given to what he is saying. This is to get the participant to focus on the subject matter. Therefore, the researcher should have the ability to clearly structure questions, listen attentively, pause, probe and encourage the interviewee to talk freely.

However, interviews can be time-consuming and are also resource intensive (Bryman, 2012). In the process of conducting interviews it is proper for the researcher to explain the purpose of the interview to the interviewee, clarify the layout of the interview, choose a location with little or no disturbance, address the terms of confidentiality, specify how long the interview will take, permit the interviewee to clear up any reservations about the interview (Dawson, 2009), and organize a method for recording the interview (take notes and/or video-recording).

Bryman (2012) outlines some of the advantages of collecting data through the interview: (1) It will provide the opportunity to generate rich data; (2) Language use by participants (interviewer and interviewees) will be considered essential in gauging the perceptions and values of the interviewees; (3) Background and interactive aspects will be important to understanding interviewee's opinions; (4) Data that will be generated can be analysed in different ways; and (5) Interviews promote the standardization of both the asking of questions and the recording of answers (field notes, video-recording and photography). The purpose of the interviews with the teachers was to triangulate the teachers' responses with their lesson observations about how their instructional and beliefs

practices are influenced by high-stakes assessments in Kaduna State senior secondary schools.

#### **4.4.4 Archived documents**

Documents are records of events or processes (Cohen & Manion, 2003). Such records may be produced by individuals or groups. Documentary evidence was used in this research to supplement information obtained by other methods. Having made the lesson observations and interviewed participants, the researcher collected and reviewed documents related to the instructional, preparatory and assessment practices for WAEC high-stakes examinations. These archived documents included: Nigerian senior secondary school mathematics curriculum, WAEC syllabus, Chief Examiners Reports and samples of WASSCE question papers.

Documents were useful to look at some aspects which the researcher might have omitted during observations and interviews, and in providing a policy context. For this study, documents were used as supplementary data alongside the main methods to triangulate data from observations and interviews. As Marshall and Rossman (2015) state, researchers supplement participant observation and interviews with collection and analysing documents produced during everyday events or constructed specifically for the research at hand. In the same vein, Patton (2002) explains that documents are a basic source of information about programme decisions and background, or activities and processes. Hence, the necessity of using the archived documents in this study.

#### **4.5 Piloting of research instruments**

Validation of the qualitative research instruments is necessary to determine the trustworthiness of the instruments used for this study. This validation was done through a pilot study. The trustworthiness of instruments (lesson observation, teachers' interviews, school's instructional facilities and archived documents schedules) were established by pilot testing them in two senior secondary schools other than the ten senior secondary schools selected for this study and using experts in mathematics to address the following questions: Are the instruments trustworthy? In other words, do the instruments measure what they are intended to measure? Do the instruments adequately

represent the contents of the study? Are the instruments appropriate for the population at hand? Are the instruments comprehensive enough to collect all the information that is required to address the aim, objectives and questions of the study? Figure 4.3 shows the procedures followed to determine the trustworthiness of the instruments used in this study.

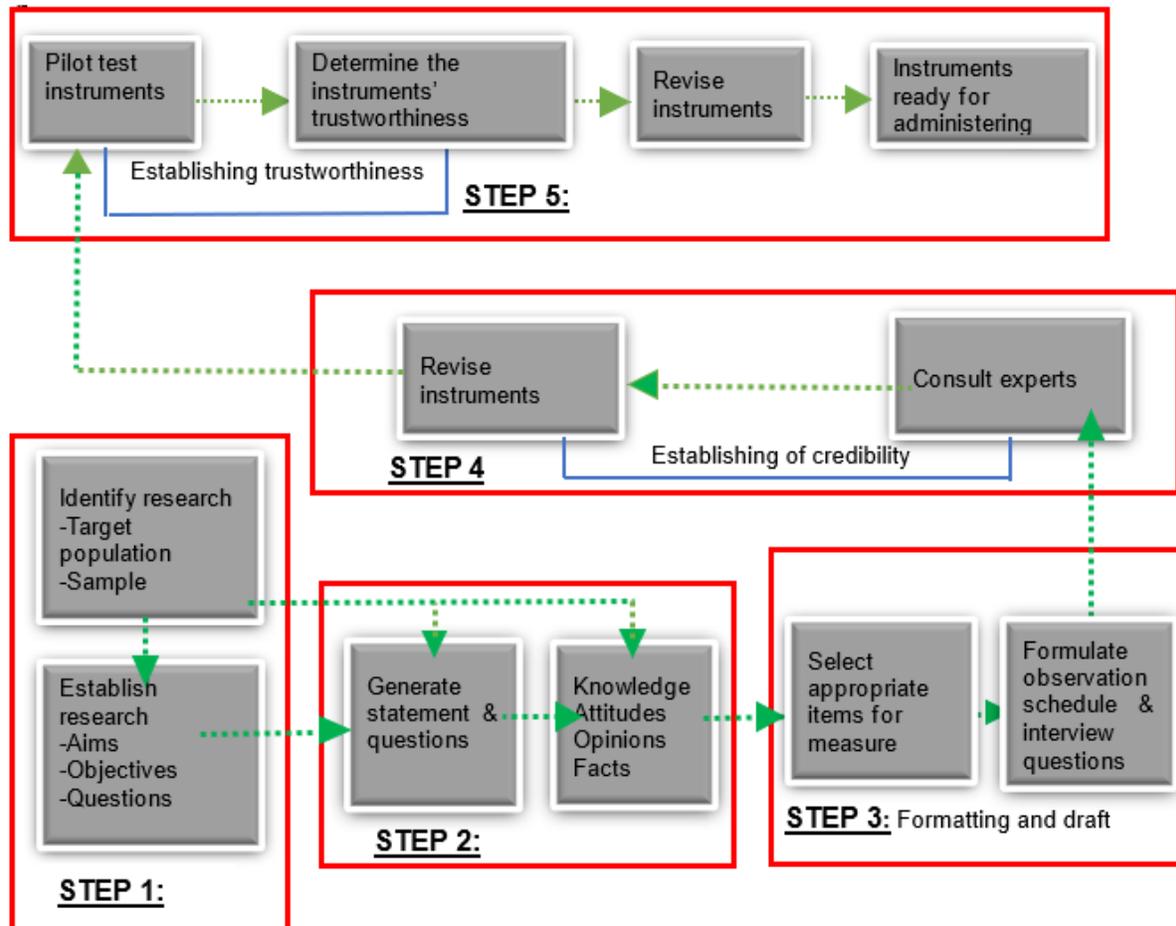


Figure 4. 3 Determining the trustworthiness of research instruments (Adapted from (Radhakrishna, 2007 p. 2)

Before constructing the instruments with which to elicit the required data, the researcher bore in mind how research instruments could effectively elicit the data sought, and how adequately the instruments matched the construct that conceptually defined the study; the instruments were piloted with a population similar to the one being studied. Hence, the pilot study was conducted on two senior secondary schools other than the ones used for this study.

#### 4.5.1 Pilot study

A pilot study can reveal deficiencies in the design of a proposed procedure and these can be addressed in good time before the actual field work (Aysel, 2012), so that the pilot study can be effectively implemented in the actual study. On completion of the draft observation, interview and archived documents schedules, their trustworthiness was ascertained by means of consulting the necessary experts, and by pilot testing them in two senior secondary schools (school P<sub>1</sub> and P<sub>2</sub> and teacher T<sub>1</sub> and T<sub>2</sub>) other than the ten senior secondary schools selected for this study. After permission was granted to carry out the study by the Kaduna State Ministry of Science, Technology and Education, the senior secondary school principals and the Stellenbosch University Research Ethics Committee (REC), the researcher went out to conduct the pilot study.

The pilot study was conducted to provide the researcher with feedback regarding the interview questions which were developed for the study. Specific information sought from the pilot study related to the following aspects: (1) whether the developed questions were clear and concise (adequate number of questions and whether appropriate language was used in the questions); (2) find out problems and barriers related to participants' recruitment; (3) being engaged in research as a qualitative researcher; (4) assessing the acceptability of observation or interview protocol; and (5) determining the methodology of the research. Pilot studies in qualitative ethnographic research allow the development of familiarity with fieldwork.

The participants in the pilot study were given an overview of the study by the researcher and allowed time to ask any questions regarding the study prior to completing the interviews and lesson observations. Additionally, the sample interview and observation protocols were used in the pilot study. The researcher and participants were able to complete the interviews and the lesson observations within the stipulated time frame.

Participants did not indicate any difficulty in understanding the items and the researcher did not receive any queries or suggestions about the format of the questions. However, this pilot study gave the researcher prior knowledge of the study area and the language in some of the interview questions was restructured to suit the study. In the coding system

used, the researcher discovered that teacher instructional practices (TIP) and teacher pedagogical practices (TPP) meant the same thing and therefore discarded the teacher pedagogical practices (TPP). This pilot study worked very well from the point of trialling the video and photo cameras and time management.

#### **4.6 Data-analysis procedures**

The instruments used for this study were designed so that the researcher can comfortably capture the necessary data that could be used as evidence to substantiate claims. This is because, as Brown (1992, p. 163) reminds us, it is a “non-trivial task to capture rich social and intellectual life of a classroom with a level of analysis that would permit one to look at real conceptual change taking place over time”. As this study is on the effects of high-stakes assessment on mathematics instructional and assessment practices, the data were analysed through descriptive, reflective and conceptual analysis.

Howard (1995) states that in an ethnographic case study research analysis has three broad categories: descriptive, reflective and conceptual. To analyse the data gathered in this study, what was done accordingly. The descriptive part of data refers to the recordings of the site, the geography of the location and the description of the participants (see sections 4.3 and 5.2). The reflective category served as period of data collection while the researcher stays at the study site. The data generated from lesson observations, interviews and archived documents collected, together with informal conversations were reflective to generate an overall impression and to generate results and findings. The analytical category refers to the initial interpretations linking all gathered data to lead to initial interpretations of findings. As the researcher was studying the effect of high-stakes assessment on mathematics instructional and assessment practices, these practices became the basis for coding participants' responses.

Codes are labels that attach symbolic meaning to field notes from observations and transcripts from interviews (Miles, Huberman, & Saldana, 2014). This is an interpretative process that acts like a filing system that emerges from nature. Thematic coding is defined as a process or method of categorizing segments of data and then assigning names or labels to pieces of data in order to attach meaning to those pieces of data to facilitate

analysis (Punch, 2005). Saldana (2009) further outlined coding into first cycle, second cycle, post-coding and pre-writing. The first cycle has seven methods and twenty-three coding systems. In this study the researcher used dramaturgical coding, categorizing and interpreting the data to provide explanations in relation to the research questions asked (McMillan & Schumacher, 2006; Saldana, 2009). According to Saldana (2009), dramaturgical coding is a coding system that explores intrapersonal and interpersonal participant experiences and actions in case studies, especially when participants engage in daily routine activities. Saldana further explains that dramaturgical coding is applied in data generated from observations and interviews using field notes, interviews transcripts and video recordings. The researcher chose this coding because it was appropriate for his qualitative ethnographic case study. For example, in the lesson observations, an action that is related to teachers' instructional practices was coded as TIP, teachers' assessment practices were coded TAP, etc. (see Table 4.1). These codes are segments of the text data that are inductively lifted from the collection and group according to emergent themes that provide descriptions of the senior secondary school mathematics classroom culture. The following coding in Table 4.1.

Table 4.1: Coding and categorizations of lesson observations

Teachers	Coding
Instructional practices	TIP
Assessment practices	TAP
Accessing students' understandings of concepts	TA
Probes students' understandings	TP
Connect students' understandings	TC
Assessing student' understandings	TAS
Reflecting on practice	TR
Professional development	TPD
Students active participation	SAP

The information from the lesson observations and interviews were transcribed and coded using the coding system in Table 4.1.

Responses from interview and observation schedules as well as archived documents are qualitative data and were analysed through conceptual content analysis (narratives) in so far as they addressed the research questions posed. Creswell (2003) defines conceptual/thematic content analysis as a technique for making inferences by systematically and objectively identifying specific characteristics of messages and using the same to establish trends.

After collecting and recording the data, the researcher is often left with a vast amount of data. As a result, researchers have to use qualitative data-analysis techniques such as thematic coding. This study utilizes the framework proposed by Creswell (2014, p. 248) for analysing qualitative data. The components of the framework include: (a) Organizing and preparing the data for analysis; (b) Reading through the data thoroughly; (c) Starting to code all the data; (d) Creating overarching themes from the data; (e) Finding possible and plausible explanations for the findings; (f) Ensuring trustworthiness in the data analysis and in the findings; and (g) Interpretation of the findings. Table 4.2 outlines the overarching themes for data analysis.

Table 4.2: Themes used for data analysis

<b>Themes</b>	<b>Data sources</b>	<b>Questions guiding the analysis</b>
Objective of the lesson	Classroom observations	What was the focus of the lesson? Did teachers focus on teaching only procedure, not meaning? Did teachers focus on teaching procedure and meaning (i.e. why they were using the procedure, explaining the procedure, or both)
Teachers' beliefs	Classroom observations and interview	How did teachers' beliefs influence their instructional and assessment practices? Did teachers' beliefs increase their effectiveness, self-confidence, and self-efficacy? Did teachers see how mathematical ideas were accessed, probed and connected?
Instructional practices	Classroom observations and interview	To what extent did tasks focus on understanding important and relevant mathematical concepts, processes, and relationships? Did tasks stimulate complex, non-algorithmic thinking? Did the teacher choose mathematically proper tasks to teach concept?

		Were the tasks appropriate for the students' level of understanding?
Student engagement	Classroom observations and interview	Were the majority of the students engaged in the lesson and did they remain on task? To what extent did students share their observations? To what extent did students explain their ideas or procedures? Were students willing to openly discuss their thinking and reasoning? Did interactions reflect a productive working relationship among students?
Mathematics sense-making	Classroom observation and interview	What was the mathematical quality of the lesson? Was the teacher able to clearly articulate what mathematical ideas and/or procedures the students were expected to learn? Did the teacher create an environment that helped students make sense of the concepts that they were expected to learn? To what extent did tasks encourage the students to think beyond the immediate problem and make connections to other related mathematical concepts? To what extent did students make generalizations regarding mathematical ideas? What was the teacher's focus when he was analysing his student's work? Did the teacher productively probe the mathematics in students' responses?
Textbooks used	Classroom observations and interview	How closely did the teacher follow the textbook? How adequate and relevant was use of the textbooks? Are they using the recommended textbooks?
Use of lesson time	Classroom observations	How did the teacher use the lesson time? How much of the lesson time was really devoted to effective teaching and meaningful learning of mathematics? How much time was devoted to activities such as emphasis on high-stakes assessments and revision?
Professional development	Interview	Do teachers have opportunities for in-service training? Who are does responsible for PD?
National curriculum/WAEC syllabus	Documents	How did the national curriculum align with the WAEC syllabus? Is the WAEC syllabus an off-shoot of the national curriculum?
WAEC Examiner's Reports	Chief Documents	How progressive is the performance of students in mathematics?

School's facilities	Documents	How adequate are the school facilities for effective instructional and assessment practices?
Sample question papers	Documents	How do the exam question reflect the curriculum/WAEC syllabus?

Table 4.2 presents the themes for data analysis. The themes include the source of data collected and questions that guided the data analysis. From the data collected during the lesson observations, coding revealed what mathematics is taught, how it is taught and how it is continuously assessed. The views and beliefs were delivered through the voice of the participants, where diverse perspectives were captured and respected throughout the coding process. The participants provided information related to their experiences and knowledge of the classroom instructional practices.

#### 4.7 Trustworthiness

Trustworthiness is process whereby qualitative researchers control potential sources of bias in a study's design, implementation, analysis and interpretation using a model described by Guba and Lincoln (1981) and Lincoln and Guba (1985). This model is based on identification of four aspects of trustworthiness: (1) credibility is having confidence in the truth of findings; (2) transferability is that the findings have applicability in other context; (3) dependability is that the findings are consistent and could be repeated elsewhere; and (4) confirmability is a degree of neutrality or the extent to which the findings of a study are shaped by the participants and not researcher's bias, motivation or interest (Guba & Lincoln, 1981; Lincoln & Guba, 1985; Schoenfeld et al., 2008). Appropriate measures were taken to ensure trustworthiness during the conduct of the research, the analysis of data and during reporting of the findings. Ensuring quality is a fundamental issue in any research process. The model is summarized in Table 4.3.

Table 4.3: Measures for enhancing trustworthiness in qualitative research

<b>Qualitative</b>	<b>Strategies used to enhance quality in this study</b>
Credibility	Prolonged engagement in the research sites Using multiple sources and methods Collection of referential material Peer debriefing Clarifying researcher's position
Transferability	Thick description of data Detailed description of context and research process
Dependability	Clarifying researcher's position Establishing audit trail
Confirmability	Detailed description of context and research process Corroboration by the literature

From Table 4.3, the four criteria of trustworthiness used to ensure quality in a study are credibility, transferability, dependability, and confirmability (Merriam, 2009). These are explained below.

#### **4.7.1 Credibility**

Credibility is a way for qualitative investigators to ensure that their instrument measures or tests what it is intended to (Shenton, 2004). Credibility, therefore, seeks to convince that the findings depict the truth of the reality under study (Bless, Higson-Smith, & Sithole, 2013). It encompasses whether the results of the study are legitimate because of the way in which the participants were selected, the data were recorded, or the analysis was done. Credibility attempts to establish the truth of the findings, based on the research design, the method (interviews, classroom observation) and context. Several strategies for ensuring credibility are explained by Lincoln and Guba (1986), Merriam (1995) and Shenton (2004), and are used in this study. The strategies include triangulation, peer/colleague review, researcher's experiences, assumptions and biases. The first strategy is triangulation, which involves the use of multiple investigators, multiple sources of data, or multiple methods for confirming the emerging themes.

Triangulation is achieved through the application and combination of research instruments such as participant observation, field notes, audio and/or video recordings,

interviews, amongst others (DuFon, 2002; Mckernan, 1996). Triangulation is a procedure for organizing different types of evidence into a more coherent frame of reference or relationship so that they can be compared and contrasted with the instruments used for generating data (Mckernan, 1996) and minimize inherent weaknesses, intrinsic biases and related problems brought about by only using one method, observer or theory.

For example, if researchers hear of a phenomenon in the interviews that they conduct, and they see the same phenomenon taking place in the lesson observations and read about it in pertinent documents, they can be confident that the phenomenon reflects the reality of the situation on the ground. Hence, this study used interviews, observations and archived documents to collect data on how mathematics teachers' instructional and assessment practices are influenced by WAEC high-stakes examinations.

Secondly, member checks involve taking data from the study participants and from the tentative interpretation of the data back to those from whom they were derived to ask if the interpretations are an accurate reflection of what they said. The researcher gave the participants the transcripts derived from the lesson observations field notes, interviews and video recording; they confirmed that they were a reflection of their classroom practices. For example, Teacher A response during member checking:

*This is exactly our instructional and preparatory practices in graduating class writing the WASSCE and other examinations that will make our students qualify for tertiary institutions admissions. We also have to adopt the strategies of rushing our lessons presentations and mostly use past examinations question papers to enable us to cover the content of the mathematics curriculum. We use the past examinations question papers because they cut across the content of the syllabus [mathematics curriculum]. It is also a short cut to cover the syllabus.*

This is representative of the responses from the participants on member checking. The purpose of the member checking was to ensure the quality of the instruments and the data collected. Audit trails were maintained so that other researchers could easily have access to data and without difficulty in interpreting them. Thirdly, peer/colleague examination/review (peer debriefing) entails asking peers or colleagues to examine the

data available, and to comment on the plausibility of the emerging themes. It also helps the researcher to maintain objectivity throughout the analysis of data and in developing resulting themes. The researcher gave his colleagues the lesson observations and interviews transcripts, field notes and the video-recordings to peer review in order to ensure quality. In the process of peer reviewing the doctoral students in Stellenbosch University critiqued and gave feedback for improvement of the quality of information in this study. The researcher incorporated several strategies to balance subjectivity with fairness and integrity. This authenticated the effectiveness of the research instruments and data collected.

Fourthly, stating the researcher's experiences, assumptions and biases is a means of presenting the orientation and biases, among other aspects, of the researcher's outlook at the outset of the study. This enables the reader to better understand the point of view from which data might have been interpreted. Fifthly, submission/engagement in the research situation relates to the collecting of data over a long period of time to ensure an in-depth understanding of the phenomenon.

#### **4.7.2 Transferability**

Transferability is the applicability of a study's findings to other situations. Researchers are concerned with the extent to which the results of the work at hand can be applied to a wider population (Shenton, 2004) and they inquire whether the results that are given by the study are transferable to other groups (i.e. populations) of interest. This qualitative ethnographic case study describes results for a small number of participants (ten mathematics teachers) and their instructional, preparatory and assessment practices. Despite the limits of generalizing findings to a large population in a case study, it could be possible to make generalizations to theory. Therefore, this study is a contribution to existing knowledge in mathematics education and other related disciplines in the education system and acts as a framework for initial teacher education and continuing professional development in handling mathematics classroom instructional and assessment practices. Lincoln and Guba (1986) suggest that it is the researcher's responsibility to provide sufficient contextual information about the fieldwork sites to let the reader determine transferability. A strategy suggested by Shenton (2004) to help

ensure transferability is a thick description of the phenomenon being studied. Lincoln and Guba (1986) also recommend that a narrative be developed about the context so that readers can judge whether or not to apply all or part of the findings to other contexts. The researcher in this study provided an extensive description of findings to enable readers to assess the resonance of the findings with similar settings.

#### **4.7.3 Dependability**

Dependability deals with core issues such as ensuring that the way in which a study is conducted is consistent across time, researchers and analysis techniques (Morrow, 2005). This explains the consistency with which other researchers can conduct the same research using the method to arrive at similar findings. Dependability demands that the researcher thoroughly describes and precisely follows a clear and critical research strategy (Bless et al., 2013). In other words, dependability refers to the idea of another researcher being able to repeat the same work, in the same context, with the same methods and participants, and get similar results. Shenton (2004) suggests that the researcher ought to report the processes adopted for the study in detail so that future researchers would be able to repeat the work. In addition to giving a detailed research report, the researcher should be able to give clear and concise suggestions for further study that will guide other researchers in subsequent studies.

#### **4.7.4 Confirmability**

The researcher affirmed that what he saw, heard and experienced was based on empirical data and not simply expressing his own opinion. Confirmability is like replicability, and it requires that the other researchers are able to obtain similar findings by following similar research processes in a similar context (Bless et al., 2013). It is based on the perspective that the integrity of findings lies in data and that the researcher must adequately tie together data and analytical processes in such a way that the reader is able to confirm the adequacy and accuracy of the findings (Morrow, 2005). In qualitative research confirmability refers to the researchers' concern with objectivity. This ensures that the ideas expressed in terms of findings result from the experiences and ideas of the participants rather than from researcher bias (Shenton, 2004).

Triangulation can, therefore, be used to promote the credibility, transferability, dependability and confirmability of the research. The researcher triangulated data from different sources, namely, ten mathematics teachers' lesson observations, interviews and archived documents from the ten Kaduna State senior secondary schools, Nigeria. The researcher applied various techniques and instruments and the process of triangulation in order to ensure greater trustworthiness. The participants equally confirmed that their actions, responses and interpretation were true reflection of their practices.

#### 4.8 Schedule for data collection

The schedule for data collection is a timeline and guided the researcher on the lesson observations, teachers' interviews, collection of archived documents and the schools' instructional facilities. Table 4.4 below represents the timeline for the data collection. The data-collection process is briefly discussed after the table.

Table 4.4 Timeline for data collection

Sources	2017	2018
Initial visit	November	Nil
Lesson observation	November – December	January
Video-recording and photography	November – December	January
Interview	Nil	January
Archived documents	November – December	January
Schools' instructional facilities	November – December	Nil

Table 4.4 presents the schedule for the lesson observations, teachers' interviews, and collection of archived documents and schools' instructional facilities. The researcher made initial visits of the participating senior secondary schools in order to contact the mathematics teachers through their school principals. This involved securing permission to conduct the study and filling in and signing the preliminary paperwork (participants' consent forms and principals' permission forms). As the initial paperwork was completed, a date was set with each teacher for the baseline classroom visit using the individual school's timetable.

The lesson observation data were collected from November 2017 to January 2018. The lessons were conducted using four visits (baseline visit, second, third and final visit) for all participating teachers who taught mathematics during the fieldwork. The final classroom observation cycle was used for the teachers' interviews. Lesson observation protocol (see Appendix D) was used by the researcher for the observations. The lesson observations focused on teachers' instructional and assessment practices, particularly as captured in the observation protocol (see Appendix D). The researcher kept a log of each observed lesson, recorded the problems and tasks teachers used in the lessons while paying close attention to how the teachers responded to their students' ideas, what they said in return and reflected on the classroom discourse. The classroom discourse is the teacher-students, student-student, whole-group or small group interactions around the content of mathematics in the classroom. In addition, the researcher used video-recordings to check the field notes. The field notes were carefully written on the same day as the observed lesson to reduce the possibility of data loss. The video-recordings and photographs were used only for transcription.

The researcher conducted individual interviews with the ten mathematics teachers who taught the SS3 students after completing the lesson observations in January 2018. He conducted oral interviews, which lasted for a minimum of one hour. The mathematics teachers' interview protocol (see Appendix E) of 36 questions was used for the interview. The interviews captured mathematics teachers' instructional and assessment practices in the classroom and how these were influenced by the WAEC high-stakes examinations and teachers' beliefs regarding how mathematics should be taught. The interview also captured teachers' views about the opportunities and challenges they faced in their CA practices.

The archived documents and information on the school's instructional facilities were collected throughout the period of the fieldwork (November 2017 to January 2018). It was very difficult for the researcher to gain access to these documents at the same time. He got them from different schools at different times. Either the teachers and/or their principals had problems with record keeping or they were not ready to make those documents and pieces of information available to the researcher. These archived

documents and the school instructional facilities are very important in this study because they facilitated or constrained effective teaching and meaningful learning in the school system.

#### **4.9 Field entry**

In qualitative research successful fieldwork is usually determined by the accessibility of the setting and the researcher's ability to develop rapport and maintain relationships with gatekeepers (De Vos & Strydom, 1998). The researcher strove to establish a cordial atmosphere and to lay the foundation for a relationship of trust, and as far as possible create a sense of equality between him and the participants (Leininger, 1996). When people feel comfortable, they are more willing to share their views without reservation.

It was important for the researcher to build up a relationship of trust with the participants, as the study applied the observation-participation-reflection model (Leininger, 1996) as an essential guide to enable the researcher to enter school settings and engage with participants while collecting data. The researcher gradually moved from being an observer and listener to a participant and reflector.

#### **4.10 Ethical considerations**

Proper research clearance and ethical consideration procedures were followed. The researcher sought for ethical clearance from the Research Ethical Committee (REC), Humanities of Stellenbosch University through the Department of Curriculum Studies, Faculty of Education, and Stellenbosch University, South Africa, to carry out the research. The researcher also requested a research permit from Kaduna State Ministry of Science, Technology and Education to the state zonal inspectorate offices and the selected schools. The permit legally allowed the researcher to conduct the research. During the research process, the participants were assured of confidentiality of information given. The ethical issues of informed consent, deception, confidentiality, anonymity, privacy and caring (Christians, 2000; McMillan & Schumacher, 2006) were addressed according to the ethical code of Stellenbosch University, hence the following ethical conditions and considerations were met during this research.

**Participant's consent**

The participants were provided with an opportunity to give their consent to freely participate in the research. They were, therefore, not involved in the research without their consent, and neither were they coerced into participating in it, nor were they induced into committing acts that diminished their self-esteem. The participants voluntarily participated in the research and were informed of their freedom to withdraw from the research at any time (Allan, 2008). The research participants were thoroughly informed of the nature of the research and the steps in the research process. According to Allan (2008), the participants have the right to anonymity in any presentation or publication that may be based on this research.

**Participant's anonymity**

The participants' right to remain anonymous was respected throughout the research. The participants were given pseudonyms. In the interest of ensuring anonymity and confidentiality, the participating senior secondary schools were referred to as School 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10, and the mathematics teachers were referred to as teacher A, B, C, D, E, F, G, H, I and J.

**Transparency**

Transparency was ensured by openly discussing the purpose, the objectives and the goals of the research with everyone who was involved in the research. At no time did the researcher withhold information about the true nature of the research.

**Honesty and uprightness**

The evaluation of the research was carried out with the honesty and uprightness expected in research. There was no fabrication, falsification or misrepresentation of evidence, data, findings and conclusions. There was no tampering with the evidence. The researcher communicated the findings in clear, straightforward and appropriate language to all stakeholders.

### **Participant's respect, safety, dignity and self-worth**

The researcher respected and safeguarded the safety, dignity and self-worth of all the research participants by being mindful of the cultural, religious, gender and other significant differences present in the research population.

### **Adhering to ethical standards**

Ethical considerations were adhered to during the study. Before starting the data collection, permissions were obtained from the Kaduna State Ministry of Science, Technology and Education, the Zonal Offices, the senior secondary school principals, and the participating teachers (see Appendices A to F). Eiselen and Uys (2005) point out that the rights of respondents as human beings should always be respected.

As stated on the informed consent form and consent sheet, the researcher adhered to the rights standards: (1) The senior secondary school mathematics teachers who participated in the research were made aware of what was required of them in relation thereto. Each individual teacher was informed that the decision to take part in the research was their own choice, and that not participating in it would not affect them in any way; (2) Each teacher was made aware that, should they wish to withdraw from the study at any time and not provide their reasons for such withdrawal, that they would be able to do so freely, without fear of being victimized regarding their decision not to participate in the research any further; (3) At no time did the researcher coerce any teacher into providing information, especially information that might be perceived as sensitive or incriminating; and (4) Each individual teacher was given the assurance that their responses would remain anonymous, and that the information that they provided would be treated as confidential at all times.

The above rights were adhered to not only to protect the human rights and welfare of the teachers, but also to minimize the risk of physical and mental discomfort, harm and/or danger from the research procedures (Canterbury Christ Church University, 2006).

### **4.11 Scientific integrity**

Scientific honesty refers to the publication of true findings and avoidance of plagiarism (Mouton & Schumacher, 2011; Babbie & Mouton, 2001). Qualitative research involves

honesty in data collection, analysis and interpretation and giving the view of the phenomenon. In this study care was taken to portray the participants' views and not the researcher's. Findings were represented fully and not misrepresented. The researcher adhered to the required technical standards and all sources consulted were acknowledged.

#### **4.12 Conclusion**

This chapter defined and described research methods, data-collection instruments and data-analysis procedures. A qualitative ethnographic case study was adopted as a design through which the researcher collects data and analyses procedures to answer the question: What are the mathematics teachers' instructional practices in preparation for high-stakes assessments in Nigerian senior secondary schools? The research methodology helps a researcher understand the processes to follow in the research processes. Ten senior secondary school three (SSS3) mathematics teachers were purposively selected from the ten schools to participate in the study. The interpretive paradigm in this study focused on understanding of internal reality, subjective experiences through qualitative, observations, interviews and documents analysis. The instruments used for the data collection were validated to determine their trustworthiness.

The qualitative data collected provided narrative accounts that supported the instructional behaviours and practices that were observed during lesson observations and interviews. Observation schedules supported by mathematics teachers' interviews were used to collect data about the extent to which the WAEC high-stakes mathematics WASSCE affect mathematics teachers' instructional practices. This research was also intended to investigate the effect of WAEC high-stakes examinations on teachers' beliefs about what it means to teach mathematics effectively and to identify the opportunities and challenges faced by teachers CA practices in the classroom and at WAEC's WASSCE. Content analysis was used to make sense of the data collected by transforming data into answers to the research questions. Included in this chapter is a discussion on adhering to ethical standards and scientific integrity.

The next chapter will deal with data analysis. The literature consulted (Creswell, 2014; Denzin & Lincoln, 2011; Patton, 2002) explains that qualitative analysis transforms data into findings and that the challenge of qualitative analysis lies in making sense of a huge amount of verbal data. The study is also an ethnographic case study, which involves an in-depth interaction with the study area and participants, hence the next chapter will present the data analysis and interpretation of findings.

## CHAPTER 5

### DATA ANALYSIS AND INTERPRETATION OF FINDINGS

#### 5.1 Introduction

This chapter analysed the data collected for the study. The data were obtained from the lesson observations and the teacher interviews, as well as the archived documents requested from the Nigerian senior secondary school mathematics teachers (participants) and their principals. The documents analysis appears in Chapter One (see section 1.4.6) as background information for this study. The characteristics of the participants are also presented including the identification of their qualifications, experience and location of the schools. The study focused on only the senior secondary school 3 (SSS3) students – the graduating class (equivalent to Grade 12).

As mentioned earlier, the researcher spent three months (November 2017 to January 2018) conducting in-depth observations and interviews with ten Kaduna State senior secondary school mathematics teachers. November and December 2017 were the first term while January 2018 was the beginning of second term (see section 1.4.7). The researcher as an observer and ethnographer participated in staff briefings to interact with the teachers and have a better understanding of the daily activities of the teachers in each school. The purpose was to develop an in-depth understanding of the activities of the school system and be able to report the findings accurately.

The general discussion during the staff briefings were informative. Principals or the Vice-Principal always start the briefings with information from the State Ministry of Science, Technology and Education, or from the zonal inspectorate division before discussing the activities of the day. Information dealt with staff and punctuality, effectiveness of routine duties in the school, professional integrity, professional development, staff and students' discipline, conduct of CA tests, and internal and external examinations. The emphasis by principals during the briefings was on the fact that assessment is what matters in education reference to their beliefs and actions in line with such demands.

The researcher observed the daily routine duties and activities of the schools. There was good management and coordination of human and material resources. The principals and

the staff were observed as being keen to see the smooth running of the academic activities at the schools – activities such as the principal and staff conducting student assemblies, staff recording students' attendance, staff attending to lessons and any other duty assigned by the school authority. The principals, the supporting staff and the teachers create a safe instructional practice environment and managed the available facilities for effective teaching and meaningful learning, which will enhance prospects for students' success in the WAEC high-stakes examinations and other examinations. There was evidence of team work among staff and there was no serious disciplinary problem observed among the students. The researcher paid more attention to the lessons observed. He observed, listened, took field notes and video-recorded mathematics lessons. The essence was to observe actions, reactions and interactions that occurred during mathematics teachers' encounters with their classes and other colleagues, and to develop more rapport with the participants and the schools.

The lesson observations and interviews took place in the participants' classrooms and offices, respectively. As mentioned earlier, the archived documents (national mathematics curriculum, WAEC syllabus, Chiefs Examiner Reports and samples of May/June WASSCE past questions papers) were also collected from the participants and/or their principals and discussed in Chapter One (see section 1.4.6). This provided a natural environment for the discourse on instructional and assessment practices.

This chapter reports the findings and analytical procedures and processes involved. In reporting these findings, as a qualitative research project with its own limitations, the researcher accepts the possibility of some subjectivity in the interpretations. However, the principles of trustworthiness were acknowledged in order to arrive at accurate findings and relevant recommendations. Therefore, presentations and remarks by participants are often quoted as stated in the transcripts of lesson observations and interviews, because the participants' lesson observations and interviews were the process of the study at the different stages and are of great importance. Data collected for this study should provide the necessary information and viewpoints to answer the main research question, which was stated as:

*What are teachers' instructional practices in preparation for high-stakes assessments in Nigerian senior secondary school's mathematics?*

The following three sub-questions were also posed:

*What are the effects of WAEC high-stakes examinations on mathematics teachers' instructional practices and strategies in selected Kaduna State senior secondary school classrooms?*

*What is the effect of high-stakes examinations on the Kaduna State mathematics teachers' beliefs about what it means to teach mathematics effectively?*

*What are the opportunities and challenges faced by senior secondary schools' mathematics teachers and WAEC in high-stakes continuous assessment practices?*

The analysis reflects on the ten mathematics teachers who were observed with respect to their classroom instructional and assessment practices based on lesson preparation, lesson structure, methodology, presentation, conceptual practice, content coverage, learner participation, and supportive instructional materials for effective teaching and meaningful learning of mathematics. Conceptual practices are effective teaching and meaningful learning of mathematics that will make the students successfully understand mathematical ideas and develop the ability to transfer their knowledge into new situations and apply it to new contexts. The focus is to see how these practices are influenced by WAEC High-stakes examinations.

## **5.2 Demographics of schools and participants**

The demographic data of the participating schools are concerned with the types of school (by sex and boarding facility), location (rural, suburban or urban), student population in the SS3, class size and teacher-students ratio (see Table 5.1 and 5.3). The demographic data of the participants are concerned with their age, gender, highest qualifications, professional qualifications, teaching experience and workload (see Table 5.2 and 5.3).

### 5.2.1 Participating senior secondary schools

As a qualitative ethnographic case study, the ten senior secondary schools that participated in the research were selected from Kaduna State using a purposive sampling technique (see section 4.3). The researcher had access to the sample schools, maximum cooperation was given to him and he was able to collect the necessary data for presentation, analysis and interpretation. Table 5.1 below presents some of the demographics of the schools.

Table 5.1 Demographics of schools

School	Type of school (sex)	Location	Type of school (resident)
School 1	Mixed boys/girls	Rural	Day
School 2	Boys	Rural	Boarding
School 3	Mixed boys/girls	Urban	Day
School 4	Girls	Urban	Day
School 5	Girls	Semi-urban	Boarding
School 6	Mixed boys/girls	Urban	Day
School 7	Boys	Rural	Boarding
School 8	Girls	Semi-urban	Boarding
School 9	Mixed boys/girls	Rural	Day
School 10	Mixed boys/girls	Rural	Day

Table 5.1 above gives the demographic information on the schools. The ten schools were selected for their proximity and for convenience. The 314 Kaduna State senior secondary schools were sparsely located round the state. The ten school were five mixed boys and girls schools, two boys-only and three girls-only government senior secondary schools. Five schools were from rural communities, while two were from semi-urban and three from urban areas. Six schools were day senior secondary schools and four were boarding senior secondary schools. This presentation gives a true picture of the senior secondary schools setting in Kaduna State (the study area in particular, and Nigeria in general. The demographic information gave the researcher the type of senior schools and students by sex (boys or girls or both), location (urban semi-urban or rural) and residential or not (students residing on the school premises or come from their homes to school). These are the types of students that the participants are teaching and write the same West African examination Council (WAEC) high-stakes mathematics examinations in the

May/June West African Senior School Certificate Examinations (WASSCE) from different localities, states and countries in West Africa.

### 5.2.2 Demographics of participants

The study sought the demographic information of the ten participants in order to get background information concerned their age, gender, highest qualifications, professional qualifications and years of teaching experience. The background knowledge gave the researcher insight into the calibre of teachers teaching mathematics in the sampled senior secondary schools for this study, especially their level of experience and professional qualifications. Table 5.2 below present the demographic information on the participants.

Table 5.2 Demographic details of Participants

Participant	Age	Gender	Highest qualification	Professional qualification	Teaching experience in years
Teacher A	49	Male	B Ed	B Ed	22
Teacher B	38	Male	B Sc (Ed)	B Sc (Ed)	10
Teacher C	54	Male	National dip.	Nil	34
Teacher D	54	Male	B Sc (Ed)	B Sc (Ed)	27
Teacher E	44	Male	B Sc	NCE	22
Teacher F	43	Male	B Sc	Nil	10
Teacher G	59	Male	NCE	NCE	35
Teacher H	44	Male	B Sc	Nil	14
Teacher I	28	Male	B Sc (Ed)	B Sc (Ed)	5
Teacher J	32	Male	B Sc M Eng.	Nil	3

Table 5.2 presents the demographic information on the ten participants. The ages of the participants range between 28 and 59, and they were all male teachers. These female teachers are either teaching SSS1, SSS2 or both. Participants by qualification: one had a Bachelor of Mathematics Education (B Ed), three had Bachelor of Science mathematics education (B Sc (Ed)), three had Bachelor of Science Mathematics (B Sc), one had a National Certificate in Education (NCE), one had a national diploma and one had a Bachelor of Mechanical Engineering (B Sc M Eng) degree. Participants by professional qualifications (teaching qualifications): six are professional teachers, while four are non-professionals.

Although the two non-professional participants with B Sc. Mathematics may have strong mathematical content knowledge, they may not have strong PCK because of lack of professional qualifications. The participants' years of teaching experience range between 3 and 35 years. The essence of this analysis is for the researcher to use this background information to reflect on the participants' level of effectiveness with reference to SMK and MKfT as constructs of instructional, preparatory and assessment practices. The researcher observed that the ten participating schools have all male teachers teaching mathematics in SS3 and there are only three female mathematics teachers – one in school 1, one in school 2 and one in school 3. As earlier mentioned these female teachers are either teaching SSS1, SSS2 or both. This section provided background information on the quality of teachers' content knowledge and teaching/professional preparation of the senior secondary school students for WAEC high-stakes mathematics examinations in Kaduna State, Nigeria.

### 5.2.3 Student population and teachers' workload

The student population, class size, teacher's workload and general teacher-student ratio per school is indicated in Table 5.3.

Table 5.3: Students' population and teachers' workload

Participating schools	SSS3 Student population	Student class size	Workload (lesson per week)	Teacher-students ratio
School 1	194	64	30	1:32
School 2	105	35	18	
School 3	168	56	30	
School 4	243	61	16	
School 5	315	79	24	
School 6	141	28	24	
School 7	81	40	12	
School 8	68	24	18	
School 9	176	59	5	
School 10	91	45	10	
Total	1582	491		

Table 5.3 presents the population of each selected senior secondary school. The total number of students was 1,582, the class sizes range between 24 and 79 with an average number of 49 students, even though the official teacher-students' ratio was 1:32. The teachers' workload ranged between 5 and 30 lessons with an average number of 19 lessons per week. This is to gauge how comfortable the teachers and students are in the classroom setting that can facilitate effective instructional practices of mathematics and the effect of overloading teachers with work. For example, schools 1, 3, 4, 5 and 9 were highly congested with class sizes of between 56 and 79 students. During the lesson observations it was noted that in such classes the teachers found it difficult to attend to students individually and the congestion sometimes created noise in their classes. It was only schools 6 and 8 that were fairly comfortable with the class sizes of 28 and 24 students respectively. The level of students' performance in such densely populated schools in WAEC high-stakes examinations is not part of this study. This is concerned with how WAEC high-stakes mathematics examinations influence mathematics teachers' instructional, preparatory and assessment practices in Kaduna State senior secondary schools. In other words, an important reason for providing student numbers, class sizes and lessons per week is to give the reader an idea of what the teachers have to cope and deal with when teaching.

### **5.3 School instructional facilities**

The senior secondary school instructional facilities play an important role in the teachers' instructional and assessment practices and in the conduct of high-stakes assessments in Nigeria. The availability and adequacy of these instructional facilities facilitate learning of mathematics that can enhance prospects for students' success in WAEC high-stakes mathematics examinations and also improve students' knowledge and skills in Nigerian senior secondary schools (Kolawole & Oluwatayo, 2004). Table 5.4 presents the availability, non-availability, adequacy and inadequacy of the instructional facilities in the ten selected Kaduna State senior secondary schools in Nigeria.

Table 5.4 Schools instructional facilities

Participating school	Class room	Desks & Chairs	Chalk Board	Exercise books	Text books	Instructional materials	Equipped Library	Math's lab.	Teachers	Other staff
School 1	In	In	In	In	In	In	Nil	Nil	In	Nil
School 2	Ad	In	Ad	Nil	In	In	In	Nil	In	In
School 3	In	Ad	Ad	In	In	In	In	Nil	In	In
School 4	Ad	In	In	In	Ad	In	In	Nil	In	Ad
School 5	Ad	Ad	Ad	Ad	Ad	In	In	Nil	In	In
School 6	Ad	Ad	Ad	Nil	In	In	In	Nil	In	In
School 7	In	In	Ad	In	In	In	In	Nil	In	In
School 8	Ad	Ad	Ad	Nil	In	In	In	Nil	In	In
School 9	In	In	Ad	In	In	In	In	Nil	In	Nil
School 10	Ad	Ad	Ad	Ad	In	Nil	Nil	Nil	In	Nil

Inferences for school's instructional facilities in Table 1.3 are as follows: Ad = Adequate, In = inadequate, Nil = None

Table 5.4 analysed the adequacy and inadequacy of the instructional facilities from the ten participated senior secondary schools. These data were taken from the senior secondary school instructional facilities forms (instrument 6 in Appendix D), which were filled in by the schools and verified by the researcher during observations. The buildings of the schools were renovated to a reasonable standard, with good ventilation and the schools' environment was kept clean. There were adequate classrooms in six schools and inadequate classrooms in four schools, and it follows that five schools have adequate desks and chairs, while five do not.

There were enough blackboards in eight schools based on the available classrooms, while school 7 has white boards and schools 4 and 5 have graph boards, but school 4 did not use them during the period of this study. Exercise books and textbooks were inadequate. There were inadequate instructional materials and school libraries were poorly equipped. Teachers were not using the available instructional materials and none of the ten schools had a mathematics laboratory. There were inadequate mathematics teachers and supporting staff. This showed how inadequate the instructional and

assessment facilities in the ten schools were. Additionally, schools 6 and 10 have computers, but they were not using them. This could be because of lack of electricity or lack of time. In order to manage high-stakes examination ethics (i.e. the rules and regulations of examinations) in senior secondary schools effectively, the principals, according to Amandi (2013), have to provide adequate teaching/learning facilities and regularly maintain them to enhance effective instructional and assessment practices. This will ensure that the students attain the expected standard for WAEC high-stakes examinations and the temptation to cheat in such examination will be greatly reduced.



Figure 5.1: Picture of teacher-students interaction during instructional practices

Figure 5.1 presents teacher-students interaction at four different participating schools in Kaduna State senior secondary schools in their natural setting. The picture show the quality and structure of the classrooms. As mentioned earlier, there is a need to improve the quality of teaching and learning infrastructure in the state. The two top pictures show a teacher writing on the board. The one writing from the top left is seen writing on a white board while the one from the top right in writing on a faint blackboard. The picture on the

lower left-hand side shows the students in the class listening to the teacher. The students in the right-hand side picture are in the class practising mathematics.

#### **5.4 Initial visits to participating senior secondary schools**

The researcher first visited the participating senior secondary schools in order to make contact with the mathematics teachers through their school principals. This involved institutional permission to gain access to the selected schools. After completing the school protocols, arrangements were made concerning the first lesson observation visit, using the individual school's timetable. From the time tables given the researcher, the schools used between 30 and 35 minutes per lesson and eight lessons per day with a break interval. This visit marked the beginning of the researcher's observations and interviews on how Kaduna State senior secondary school mathematics teachers' instructional, preparatory and assessment practices are influenced by WAEC high-stakes examinations

#### **5.5 Lesson observations**

The researcher collected lesson observations data from the mathematics teachers teaching senior secondary school 3 (SSS3) students for three months (November 2017 to January 2018). This is five months before the commencement of the May/June WASSCE. Section 4.3 in Chapter 4 explained in detail how the participants were chosen for this study. The aims of the lesson observations were to: (1) observe the mathematics teachers' instructional and assessment practices (Morrow, 2007; Hiebert and Grouws, 2007) in relation to WAEC high-stakes assessments; (2) identify the teachers' focus on teaching procedure and meaningful learning and how they focus on students' understanding of important and relevant mathematical concepts, processes and relationships (Schoenfeld, 2017a) for success in WAEC high-stakes mathematics examinations; (3) see how teachers' beliefs increase their effectiveness (see research question 2), self-confidence, self-efficacy (Bandura, 1993; Bosan, 2018; Steele, 2010) in their instructional and assessment practices; (4) see how mathematical ideas were assessed, probed and connected (Schoenfeld, 2017a) by teachers in their instructional and assessment practices; (5) observe how teachers in their instructional practices

engaged the students in the lesson; and (6) observe how the principals and teachers create a safe instructional practice environment and make available adequate facilities for effective teaching and meaningful learning (Sani, 2015) for success in WAEC high-stakes examinations. The focus was to observe mathematics teachers in their instructional practices, exhibiting effective teaching and meaningful learning that is reflected in the mathematics curriculum and not simply teaching to the high-stakes examinations.

During these observations the researcher video-recorded the mathematics lessons, and took photographs and field notes on the teachers' instructions (see section 4.4.2). These were used for transcriptions and as back-up for analysis only. The study focuses on the teachers rather than their students. For this analysis to be uniform in nature, the researcher used initial visits, baseline visits, second visit, third visit and final (fourth visit) lesson observations (i.e. a total of 5 visits to each school), which gives a grand total of 50 visits to the ten schools. These 50 visits were done to fulfil the requirement for micro-ethnography (see section 4.2.4) of at least a couple of weeks to a few months. The researcher did not concentrate on a particular school for the five visits before moving to another school, but rather visited the ten schools on a rotational basis.

The researcher's role as an observer and ethnographer was to make descriptive notes on the lesson observed and make reflective notes on the lessons presented. In observing the lessons, the researcher focused on teachers' instructional and assessment practices, and the problems and tasks teachers used in the lessons were captured. Attention was given to how the teachers present their lessons in the classes with respect to MKfT as constructs of mathematics instructional, preparatory and assessment practices for high-stakes assessments as well as to their interaction with the students and students' engagement in the classroom activities. The lesson observations were to gauge how the participants' instructional, preparatory and assessment practices related with Popham's (2001, 2003, 2004) framework of instructional practices, Schoenfeld's (1992, 2016, 2017a) framework of teaching for robust understanding and Bloom's (1956) taxonomy of educational objectives (see 3.2.1, 3.2.2 and 3.2.3).

## **5.6 Effect of high-stakes examinations on mathematics teachers' instructional practices and strategies**

The baseline visits were the first, when the researcher met with the participants for the first time in the classrooms for the lesson observations. These visits were also to help in developing the relationships and the rapport with the schools and the participants and to start the actual lesson observations. The lesson plans were analysed in relation to relevance to the national Mathematics curriculum topics, performance objectives, contents, instructional activities, instructional materials and evaluation. The participants recognized the use of behavioural objectives, which reflect the students' factual and metacognitive knowledge of mathematics in planning their lessons as encouraged by Bloom's taxonomy of educational objectives (1956) and revised by Krathwohl (2002). The emphasis was to see how WAEC high-stakes examinations influence the ten Kaduna State senior secondary school mathematics teachers' instructional, preparatory and assessment practices. This was done through comparing the logical connection between national Mathematics curriculum outcomes with the lesson plans, goals of the lesson, activities planned, instructional procedures, assessment and instructional materials used during instruction as suggested by Schoenfeld's (2016, 2017a) framework of teaching for robust understandings (TRU) in mathematics.

The ten participants fully participated in the schools' activities of their school. English was the language of instruction, even though it is a second language in Nigeria. The classroom sitting arrangement was in rows and columns of desks and benches facing the blackboard, except in school 3 where the classroom sitting arrangement was in roundtable format using desks and stools, facing the blackboard sideways. The participants generally used whole group instruction and individual student's learning. The researcher used the preparation for lesson observations form (see Appendix D). The importance of the lesson plan was to compare the participants' lesson preparation with the actual lesson presentation. Since the teachers already have in mind that they are preparing students for WAEC high-stakes examinations, the examinations may influence their lesson preparation.

### 5.6.1 Mathematics teachers' instructional practices and strategies

#### Lesson observation: Teacher A

Teacher A in the first cycle (i.e. first rotation in the visitations of the ten schools) prepared his lesson on addition of modular arithmetic. The teacher introduced the lesson with questions on the previous class held. This connected the students' interest to the lesson of the day as in Schoenfeld (2017a) and Bloom's (1956) taxonomy frameworks of cognitive demand, where the students have the opportunity to grapple with mathematical ideas. The teacher defined and explained with examples the concept of modular arithmetic with reference to the requirement of WAEC high-stakes mathematics examinations. He explains:

*Modular arithmetic is concerned with a basic cycle with the correct number of steps. For example, 5 mod means that a cycle has 5 steps and the principle is where in the cycle one would end. Another example is  $4 \oplus 24$  in mod 6 means that you are on the 4 in the cycle and then you go 4 times around the cycle because  $24 = 4 \times 6$ . Then you end at 4 again in the cycle. Therefore, the answer to  $4 \oplus 24$  is  $4(\text{mod } 6)$ .*

The teacher solved more examples and later gave the students class work. He deployed the students' mathematical knowledge to support more rigorous explanations. Bloom's factual knowledge on concepts of modular arithmetic was presented to the students to learn without allowing the students' time to discuss their ideas and make sense of mathematics. The connections between concepts, procedures and contexts were addressed and explained. However, in the case of Teacher A, there was breach of Schoenfeld's (2016) equitable access to mathematics dimension and this might be a result of rushing to complete the syllabus at the expense of teaching for robust understanding. The classwork questions presented are in Figure 5.2.

An operation  $\oplus$  is defined on the set  $x = (1, 2, 3, 5, 6)$  by  $m \oplus n = m + n + 2 \pmod{7}$  where  $m, n \in X$ .

- (i) Draw a table for the operation.  
 (ii) Using the table find the true set of:  
 I.  $3 \oplus n$   
 II.  $n \oplus n$

WAEC, 2015, question 11(c)

Figure 5.2: Students' classwork question on modular arithmetic (WAEC 2015, question 11(c))

Table 5.2 presents the class activity given to the students. The WAEC past questions used by the teacher showed how his instructional and assessment practices are influenced by WAEC's WASSCE. Teacher A's presentation did not engage the students for conceptual understanding and equitable access to legitimate mathematical knowledge, and the sole reference documents brought and used in the classroom were the WAEC past questions papers. The teacher used the past examination question papers more than the prescribed textbooks. The students were confused when there is a remainder in the number of cycles; one of the students stated:

Student: *Sir, my problem is how to follow the cycle and write down the remainder in the mod.*

Teacher: *You need to follow the cycle based on the number used. For example, in mod 6,  $m \oplus n = 9 \oplus 28 = 9 + 28 = 37 = 1 \pmod{6}$ , that is, the number of times we can get 6 in 37 is 6 times remainder 1 which is the  $1 \pmod{6}$ .*

The teacher explained the example to the students again:

*In solving modular arithmetic you need to apply the concept of arithmetic operation of addition and division. You can see we added the two numbers in the operation ( $\oplus$ ) 9 and 28 equals 37 and divided the result 37 by 6 equals 6 time remainder 1 ( $6 \times 6 = 36$ ). The remainder 1 is the answer in mod 6 written as  $1 \pmod{6}$ .*

Teacher: *Do you understand?*

Student: *Yes sir.*

Teacher: *Class, do you understand my explanation?*

Students: *Yes sir.*

The mathematics content dimension referred to a new mathematics topic which the teacher appeared to be comfortable with, a reflection of strong mathematical content knowledge (SMK or MCK). The cognitive demand dimension of the task was moderate as all students responded by saying 'Yes sir' to the question about whether they understood the teacher's explanation. However, whether there was equitable access to mathematics for all students is difficult to judge, when a chorus answer is given by all students to a leading question like 'Do you understand?' Hence the teaching strategy was indeterminate in so far as the equitable access to mathematics dimension was concerned.

As far as the agency, ownership and identity dimension was concerned, it is evident that a whole class approach of choral answers could not be adequate. There was only teacher to whole class interaction, but not much meaningful contribution by the learners, and hence very few opportunities for students to build on each other's contributions. From an assessment practices point of view, it is clear that the item taken from WAEC past examination question papers was intended to align teaching with high-stakes assessments. More importantly, from Popham's (2001, 2003b, 2004) framework it can be concluded that this was some form of teaching to the test in which the teacher anticipated the kind of questions of modular arithmetic that can appear in future examinations.

The lesson of the second visit was on direct and inverse variation. The teacher explained with examples:

*There are four types of variation: direct, inverse, joint and partial variation. But our concern today is with direct and inverse variation. In direct variation, if two quantities vary proportional to each other, we say that they have a direct variation. It also means that, if the value of one quantity increases, the value of the other quantity increases in the same ratio. For example,  $y \propto x \Rightarrow y = kx$  if  $x$  is the independent variable and  $y$  is the dependent variable, where  $k$  is a constant.*

He solved some examples for the students. He then continued with the inverse variation.

*In inverse variation, if two variables vary inversely, it means that, if the value of one increases, the value of the other decreases in the same ratio or increases inversely. The variables  $x$  and  $y$  vary inversely, that is,  $y \propto \frac{1}{x} \Rightarrow y = \frac{k}{x}$  that is, the corresponding value of  $y$  is multiplied by the multiplicative inverse of  $x$ , where  $k$  is constant.*

According to Table 2.3, the MKfT (Content and Teaching) and Knowledge of Content and Student are not evident in the lesson observed. The teacher had to repeat the explanation of the concept of variation with examples for the students to understand. The students were passive listeners and were only engaged in copying the examples solved by the teacher from the board. The teacher exhibited common content knowledge (CCK) in his lesson presentation as explained by Ball et al. (2008). The teacher could not deploy the students' mathematical knowledge to support more rigorous explanations and reasoning, and analyse and make use of students' mathematical ideas better than would otherwise have been possible. The students were also taught how to find the laws or relationships connecting the variables. They were given take-home assignment. The assignment given to the students was on direct and inverse variations are in Figure 5.3.

(1)  $y$  varies directly as  $x$ , if  $x = 24$  and  $y = 12$ , what is the relationship between  $x$  and  $y$ ? When  $x = 72$ , what is  $y$ ?

(2)  $y$  varies directly as  $x$  and inversely as  $z$ . if  $x = 25$ ,  $z = 10$ , what is the law connecting  $x$ ,  $y$  and  $z$ ? When  $y = 28$  and  $z = 14$ . When  $y = 36$  and  $z = 64$ , find  $x$ .

Figure 5.3: Assignment question given to the students on direct and inverse variations

The teacher initiated cognitively challenging activities in the classroom, and selected tasks to try and maintain appropriate levels of cognitive demand. These tasks were individual activities that did not allow the students to engage in groups and share ideas. Completing tasks as take-home assignment may likely allow few opportunities for students to acquire appropriate knowledge and skills in mathematics.

The lesson of the third visit was on joint variation. The teacher returned the exercise books to the students after marking the take-home assignment of the previous day's lesson. He solved the take-home assignment for the students to make corrections. These were only exercises or routine procedures. There was no application or problem solving. It was a mechanistic approach that emphasised procedures but not sense making in real life situations. They seemed to be just doing procedural drill in preparation for WAEC high-stakes examinations. Schoenfeld (2016, 2017a, 2017b) suggested that formative assessment is evaluation of students' conceptual understanding of mathematics during the learning process. Schoenfeld further explained that assessments reveal the level of students' progress or lack of it in the school system, and enable the teacher to remedy possible misconceptions. The teacher then continued with the lesson of the day. He then explained the concept of joint variation with examples. He further explained:

*In joint variation, a variable varies directly and/or inversely to each variable. That is,  $x \propto ab \Rightarrow x = kab$  or  $x \propto \frac{y}{z} \Rightarrow x = k\frac{y}{z}$ , where  $k$  is a constant.*

After solving some examples, the teacher gave the students some WAEC past examination questions to solve in the class, but they were unable to complete solving them. The students were asked complete the classwork at home and bring it for marking the next day. In line with Schoenfeld's (2017a) frameworks of teaching for conceptual understanding, students were provided with opportunities to solve problem in variation and reflect on their solutions. However, on the one hand, if students are given activities that are simple, those activities may lower their cognitive demand. On the other hand, if students are given activities that are above their cognitive level, they are likely to get stuck and there will be no meaningful learning. It is evidence that the teacher was using examination-driven instruction that focused directly on WAEC high-stakes examinations items. The classwork to be completed by the students is shown in Figure 5.4.

The cost  $c$  of producing  $n$  bricks is the sum of a fixed amount,  $h$ , and a variable amount  $y$ , where  $y$  varies directly as  $n$ . If it cost GH¢950.00 to produce 600 and GH¢1,030.00 to produce 1000 bricks,

- (i) Find the relationship between  $c$ ,  $h$  and  $n$ ;
  - (ii) Calculate the cost of producing 500 bricks.
- WAEC 2015, question 5(b)

Figure 5. 4: Questions on variation (WAEC 2015, question 5b)

In Figure 5.4, the work given to the students to complete at home was WAEC past question which was a revision against the May/June WASSCE 2018. Teacher A used traditional teacher-centred method and revision practice towards WASSCE high-stakes examinations. This means that the teacher was just explaining and solving the questions on the board without calling for student input, whether right or not. The teacher did not actively engage the students in meaningful learning that would support their growth in mathematics. However, he focused on teaching procedure and meaning and tasks to stimulate complex, algorithmic thinking and revision practice for the WASSCE high-stakes examinations. The instructional approach seemed to be examination-driven instructions and revision practice in preparing the students for the WAEC high-stakes examinations in May/June 2018. Teacher A's lesson presentation showed how his instructional and preparatory practices were influenced by WAEC high-stakes examinations. Although in item-teaching, teachers organize their instruction either around the actual items found in an examination paper or around a set of look-alike items.

### **Lesson observation: Teacher B**

Teacher B prepared his lesson for the first visit on multiplication of matrices, a whole group instruction using the lecture method. The teacher defined a matrix as follows:

*A matrix is a rectangular array of numbers that are enclosed within brackets. For*

*example,  $\begin{pmatrix} 1 & 2 & 3 \\ 3 & 5 & 6 \\ 7 & 4 & 8 \end{pmatrix}$  is a 3 x 3 matrix.*

He further explained to the students that:

*When we write down the order of a matrix, we first write the number of rows (the horizontal) and then the number of columns (vertical). This is similar to writing down the coordinates of a point. If we multiply two matrices A and B by each other, we multiply each entry of the first row of A with each entry of the first column of B and add the products. That gives us the first entry of the product of the two matrices. Then, we multiply each entry of the second row of A with each entry of the first column of B and add the products. That again gives us the second entry of the product of the two matrices.*

He also explained that:

*The transpose is obtained by interchanging the row and columns of the matrix.*

The teacher solved two examples and gave the students some class work. The content was presented to the students without student's engagement in groups or whole group discussions, where students could share ideas and become active thinkers and learners. The students' willingness to engage, ownership and identity dimension were all denied. It is evident that a whole class approach could not be adequate for sound mathematics instructional practices. There was only teacher to whole class interaction, but not much meaningful contribution by the students, and hence very few opportunities for students to build on each other's contributions. Figure 5.5 is the classwork given to the students.

<p>Let <math>A = \begin{pmatrix} 1 &amp; 4 &amp; 3 \\ 2 &amp; -3 &amp; 4 \\ 5 &amp; 0 &amp; 1 \end{pmatrix}</math> and <math>B = \begin{pmatrix} 3 &amp; -1 &amp; 2 \\ 4 &amp; 1 &amp; 3 \\ 2 &amp; -3 &amp; 5 \end{pmatrix}</math> and <math>C = \begin{pmatrix} 1 &amp; 3 &amp; 0 \\ 4 &amp; -2 &amp; -1 \\ 3 &amp; 1 &amp; -2 \end{pmatrix}</math></p> <p>Find (1) <math>AB</math> (2) <math>AC</math>. Find the (1) <math>AB^T</math> (2) <math>AC^T</math></p> <p><math>A = \begin{pmatrix} 1 &amp; 4 &amp; 3 \\ 2 &amp; -3 &amp; 4 \\ 5 &amp; 0 &amp; 1 \end{pmatrix}</math> and <math>B = \begin{pmatrix} 3 &amp; -1 &amp; 2 \\ 4 &amp; 1 &amp; 3 \\ 2 &amp; -3 &amp; 5 \end{pmatrix}</math> and <math>C = \begin{pmatrix} 1 &amp; 3 &amp; 0 \\ 4 &amp; -2 &amp; -1 \\ 3 &amp; 1 &amp; -2 \end{pmatrix}</math></p> <p>Find the (1) <math>AB</math> (2) <math>AC</math>. Find the (1) <math>2) AC^T) AC^T</math></p>
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Figure 5. 5: Classwork on multiplication of matrices and how to find transpose of matrices

The students were passive listeners and were only copying the solved questions from the blackboard. The students' passiveness during the lesson showed how the teacher did not initiate any interaction with the students in the class. What counts in instructional practices is what the students learn and the quality of the mathematics content. Where students are given opportunities to engage effectively with the content of mathematics, they are likely make sense of rich content (Schoenfeld, 2016, 2017a, 2017b). The students need to be engage in a productive struggle in mathematics. One could see a classroom where the mathematics presented was beautiful and elegant during instruction, but only a few of those listening could understand what that was taught. The students were not given the opportunity to discuss their ideas, perhaps because of the limited time he had to prepare the students for the end-of-term examination in December 2017 and the WAEC high-stakes examinations in May/June 2018

Teacher B's lesson for the second visit was on logarithms of numbers. The teacher explained the methods of multiplication, division, powers and roots of logarithm with digits less than zero with examples. The students had difficulty with the subtraction of negative numbers solving problems involving logarithms. Pertinent here are procedural and conceptual challenges around using logarithms to arrive at answers to computation. These particular procedural and conceptual challenges are subtraction of negative integers, procedural computations to arrive at the antilogarithms and the final answer. In such a situation the teacher needed to provide clarification and support by explaining the concepts vividly to the students. Schoenfeld's (2016, 2017a) TRU and Krathwohl's (2002) concept of metacognitive knowledge explains that when teachers encounter such student difficulties, the approach to remedy the problem may tend to lower the students' cognitive demand, and lose the opportunities for productive struggle and sense making in mathematics. Schoenfeld (2016) further explains that teachers should anticipate and deal with students' difficulties as they arise in teaching and to align more closely knowledge of mathematical content with knowledge of teaching, so that the best of both worlds can become relevant in mathematics instructional practices. This is what Hill *et al* (2008) refer to as knowledge of students' common misconceptions and subject specific difficulties. However, the teacher repeated the procedures, as well as the explanation of the concept and solved the example in order to clarify the difficulty as shown in Figure 5.6.

Simplify using the mathematical table  $\frac{(0.3245)^2 \times \sqrt{2.8672}}{14.3569}$

Number	Logarithm	
$(0.3245)^2$	$\bar{1}.5112 \times 2$	$\bar{1}.0224$
$\sqrt{2.8672}$	$0.4575 \div 2$	0.2288
		$\bar{1}.2512$
14.3569	1.1571	1.1571
0.0124		$\bar{2}.0941$

Figure 5.6: How to solve multiplication, division of logarithms and solving exponentials and roots of logarithms

The teacher used examples to clarify the difficulty the students' encountered with the concept of subtraction of negative numbers. He explained:

*This is how you should treat subtraction of negative numbers with bars, for example,  $(\bar{3}. 2) - (\bar{8}. 6) = (\bar{4}+1.2) - (\bar{8} +0.6) = (-4) - (-8) - (1.2) = (-4 + 8) + (1.2-0.6) = 4 + 0.6 = 4.6$ .*

The teacher gave the students some exercises and he was moving round in the class marking and correcting their work. Schoenfeld (2017) and Krathwohl (2002) explain that learning is enhanced when the teacher teaches the students by engaging them with the content at a productive level of cognitive demand. When the students are given mathematics content that is of a lower level, they will not learn very much in mathematics. This interaction was teacher-student engagement that did not allow discourse in the whole class or in groups. However, from an assessment perspective, through deliberately attending to students' reasoning and understanding made the teaching clearer, more focused and more effective (Schoenfeld, 2016, 2017a, 2017b). At a point when he saw some of the students' mistakes, he commented,

*I will not be in the examination hall to tell how to solve these questions, remember you will be on your own. You know how important these examinations are to you and the school. We need to protect our image by play our parts very well to come out with a good result in the WASSCE.*

There was no response from the students. Lack of response from the students could be that they have got stuck in their reasoning on the tasks given to them. The comment given by the teacher was a preparatory emphasis on the forthcoming WAEC high-stakes examinations in May/June 2018. At the end of the lesson the teacher gave the students an assignment to do during their prep time in the evening. This became a routine of giving students classwork and then a take-home assignment. The assignment of the students is in Figure 5.7.

Simplify following using the mathematical table:

$$1. (0.5160)^3 \times \sqrt[4]{2.9864} \quad 2. \sqrt[3]{\frac{0.9675}{(4.0214)^2}}$$

Figure 5. 7: Assignment on multiplication and division of logarithms, solving exponentials and roots of logarithms

Teacher B used blackboard illustrations and the textbook and mathematical tables. According to Schoenfeld (2016), when teachers give students class activities that involve memorization of solutions procedure in a routine that lead to one type of opportunity for student thinking, but tasks that require students' conceptual understandings stimulate them to have opportunities for multiple solution strategies. The challenge in this lesson was lack of classroom activities that are framed in ways that provide students with meaningful opportunities for learning and that support their growth through active engagement with the content. However, the teacher rushed the students by teaching four main concepts in a lesson of 35 minutes. The lesson presentation resembles the type of instructional practices Julie (2013a) called examination-driven instruction. The teacher was hurrying to cover much in order to complete the content of the curriculum before the start of the WAEC high-stakes mathematics examinations in the May/June 2018. This was confirmed from the member checking, where the participants accepted that what was transcribed was a reflection of their instructional, preparatory and assessment practices (see section 4.7.1). Teachers in their instructional and assessment are supposed to have enough time for the prescribed mathematics curriculum as content to be covered and by actively engaging the students in meaningful learning.

Teacher B's lesson on the third visit was on surds. The teacher returned the exercise books to the students after marking the assignment he had given them in the previous lesson and solved the questions so that the students who made mistakes will do corrections. After this the teacher continued with the lesson of the day. He defined and explained,

*Surds are irrational numbers that are in root form which cannot be determined exactly, such as  $\sqrt{2}, \sqrt{3}, \sqrt{5}, \sqrt{7}, \sqrt[4]{8}$  etc.*

He further explained the surd laws and simplification of surds to the lowest terms with examples.

law of multiplication:  $\sqrt{a} \times \sqrt{b} = \sqrt{a \times b}$

$$(1) \sqrt{16} \times \sqrt{49} = 4 \times 7 = 28$$

Law of division:  $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$

$$(2) \sqrt{\frac{36}{81}} = \frac{\sqrt{36}}{\sqrt{81}} = \frac{6}{9}$$

$$(3) \sqrt{a} + \sqrt{b} \neq \sqrt{a + b}, \text{ e.g. } \sqrt{25} + \sqrt{16} \neq \sqrt{25 + 16}$$

$$(4) \sqrt{a} - \sqrt{b} \neq \sqrt{a - b}, \text{ e.g. } \sqrt{100} - \sqrt{9} \neq \sqrt{100 - 9}$$

The teacher had the common content knowledge and of mathematics and had self-efficacy because he was able to confidently explain surds law with example. The teacher was just hurrying without pausing to ask the students questions or allow the students to ask questions. Students were not given the opportunity to engage in the lesson, or to develop ownership of the mathematics content in terms of Schoenfeld, (1992 2016, 2017a, 2017b) TRU framework dimensions and to be able to develop positive identities as thinkers and learners in mathematics. In the case of Teacher B, he later gave the students class activity and later added some take home assignment. Figure 5.8 presents the classwork and assignment given to the students.

Simplify to the follow to the lowest terms:

(1)  $\sqrt{72} \times \sqrt{32}$  (2)  $\sqrt{108} \times \sqrt{147}$  (3)  $\sqrt{64} \times \sqrt{148}$

(4)  $\sqrt{\frac{49}{144}}$  (5)  $\sqrt{\frac{121}{169}}$

Figure 5. 8: Classwork and the assignment on simplification of surds given to the students.

Teacher B's used traditional methods, blackboard illustrations and the textbook throughout his lesson. He focused on procedure and algorithmic thinking; students were

passive listeners but the majority of them were engaged in the lesson copying the worked-out examples from the board and seemingly remained on task (see Figure 5.5). The teacher provided detailed step-by-step instructions, and repetitive exercises that allowed little room for the students' current conceptual understanding. This could be regarded as inappropriate high-stakes preparation or instructional practice. Popham (2001, 2003) refers to this as teaching to the test or examination-driven instruction that does not engage the students for understanding or give them access to legitimate mathematical knowledge. This shows the effects of WAEC high-stakes examinations on the teacher's instructional, preparatory and assessment practices in the class taught by teacher B.

### **Lesson observation: Teacher C**

Teacher C's lesson for the first visit was on simultaneous linear equations. The teacher explained,

*Simultaneous linear equations can be solved using substitution, elimination, graphs and matrix methods. But we will use the first three methods. The questions I have picked for this lesson are similar to WAEC examination questions you should expect in June 2018. For simultaneous linear equations, two linear equations with two variables, say,  $x$  and  $y$ , then, there is only one value of  $x$  and one value of  $y$  that will make them balance or true at the same time. Also, each one of these equations can be represented by a straight-line graph and where these two lines intersect (I mean cross each other) represents the value of  $x$  and of  $y$  (I mean coordinate of  $x$  and  $y$ ) that will make them balance simultaneously.*

The teacher solved some examples using the elimination and substitution methods. Teacher knowledge needs to be broad so that mathematics teachers will conceptualize the instructional content in multiple ways, and approach and represent it in a variety of ways. Mathematics instructional knowledge should be deep so that teachers know the curricular origins and direction of the content. The SMK should not be treated in isolation from PCK, which is the other part of MkfT (Ball *et al.*, 2008; Hill *et al.*, 2008). The teacher is seen presenting mathematics content without applying the MKfT by using neither activities nor engaging the students in whole class discussion that will enhance a

productive struggle as mathematics thinkers and learners. Figure 5.9 is one of the examples solved by the teacher during the lesson.

Solve equation: $3x - 2y = 24$ and $4x - 9y = 36$ .	
Solution:	
$3x - 2y = 24$	(1)
$4x - 9y = 36$	(2)
$\times 4: 12x - 8y = 96$	(3) Or $\times 9: 27x - 18y = 216$
$\times 3: 12x - 27y = 108$	(4) $\times 2: 8x - 18y = 72$
Therefore, $x = \frac{12}{19}$ , $y = -\frac{144}{19} = 7\frac{11}{19}$	

Figure 5. 9: Example on solving simultaneous equations using elimination method

During presentation of the lesson as showed in Figure 5.9, the teacher revealed the ways in which the students should make sense of the concept of simultaneous equations as they learn but provided the students with few opportunities to express the conceptual understandings that they may have developed. However, the lesson was presented focused on procedural and algorithmic thinking. After solving the examples, the teacher further explained that:

*In answering any question in any examination, always use the method that is easier at your disposal. You know you will be working with time. In the writing general mathematics examination, you have to reason fast, write fast and follow the procedure of solving any questions to be able to obtain good mark. WAEC will not only be interested in your final answer but the steps you follow to arrive at the accurate answer.*

The teacher's instructional practices look like an examination-driven instruction because of the emphasis on how students should approach simultaneous equations questions during high-stakes examinations. According to Julie et al. (2016) underlying meaningful teaching for school mathematics is the idea that the learning environments should be structured in such a way that students are allowed to experience learning mathematics in the same way as expert mathematicians work to develop mathematics at the frontiers of the discipline. MKfT is strongly related to the quality of instruction and cannot be based on a teacher's mathematical knowledge alone (Adler, 2012; Ball et al., 2008). It may also

affect mathematics teachers' instructional practices with respect to classroom explanation, representation and the teacher's responsiveness to students' mathematical ideas. He then continued with solving questions on quadratic equations. Figure 5.10 shows the two quadratic equations he solved.

Solve for X:

1. (a)  $x - \frac{x+3}{x} + \frac{3}{x} = 5$

(b)  $x + 5 + \frac{12}{x-2} = 0$

2. (a) Solve for p, if  $p + \frac{40}{p} = 14$

(b) Now use your answer in (a) to solve for x, if  $x^2 - 3x + \frac{40}{x(x-3)} = 14$

Figure 5.10: The two quadratic equations solved the by teacher during his lesson

Teacher C used blackboard illustrations and a revision textbook for high-stakes examinations throughout his lesson presentation. He focused on procedural and algorithmic thinking toward high-stakes examinations, but encouraged the students to think beyond the immediate problem and make connections to other related mathematical concepts. The students were passive listeners. It is important to note the relationship between MKfT and high mathematical quality of instructional practices (Hill et al., 2008). Teachers with high MKfT provide better instruction to their students than those with lower MKfT. The teacher exhibited CCK in his lesson presentation, but could not deploy the students' mathematical knowledge to support more rigorous explanations and reasoning, and analyse and make use of students' mathematical ideas better than would otherwise have been possible.

Teacher C's lesson of the second visit was on revision practice which made it preparatory practice. The teacher selected some WAEC and NECO past examination questions from his file based on the topics covered during the term. This lesson was presented toward the end of first term in December 2017, when the school was about to start the end-of-term examinations. He selected some WAEC past question papers from his file and emphasized,

*You know you are starting your examination next and you are expected to answer questions that are of WASSCE standard. So, we are going to revise some of the past questions in this lesson.*

After that, the teacher spent time solving questions shown in Figure 5.11 with the students for 30 minutes.

(1) Solve: $(x - 2)(x - 3) = 12$	WAEC 2014, question 10(a)
(2) (a) Solve: $7(x + 4) \leq 2[(x - 3)(x + 5)]$	
(b) A transport company has a total of 20 vehicles made of tricycles and taxicabs. Each tricycle carries 2 passengers while each taxicab carries 4 passengers. If the 20 vehicles carry a total of 66 passengers at a time. How many tricycles does the company have?	

Figure 5. 3: Revision questions on the quadratic equations, inequality and simultaneous equations (WAEC, 2014 question 10a and WAEC 2016a & b).

He further told the students that:

*This is where we are going to stop for today. If you have some past questions, you can practise them at home.*

Then he left the classroom because the period for the lesson was over. From the teacher's statement one may assume that the teacher was applying deliberate practice (Ericsson et al., 1993). In this practice the teacher instructs the students to engage in practice activities that maximize improvement in mathematics knowledge and skills. The teacher provided classroom instructions that incorporated students practice activities with the actual items on the WAEC high-stakes examinations. It has been suggested that formative assessment involves orchestrating classroom activities that reveal the current state of students' conceptual understanding of mathematics during the learning process (Schoenfeld, 2016). Such assessments reveal the ways in which students are making sense of mathematics as they learn, they provide the teacher and the students with opportunities to build upon the understanding they have developed, and to address

emergent misunderstandings (Popham 2001, 2003, 2004; Schoenfeld, 2016). The teacher then continued with the lesson of the day. According to Popham, if a teacher uses the actual test items in classroom activities or uses items similar to the test items, the teacher is engaging in a kind of teaching called item-teaching, which might be detrimental to students' conceptual understandings of mathematics. The students were to understand the procedure and the algorithm on how to attempt questions in the high-stakes examinations but with no real-life applications involved.

The lesson for the third visit was again on revision. Teacher C continued with the revision of WAEC past questions from his file relevant to the topics taught against the end of first term examination in December 2017. He used the traditional teacher-centred method and blackboard illustrations. The students were passive listeners and they were only engaged in copying the solved questions done by the teacher from the blackboard. He did not care whether the students understood or not. There was no teacher-student or student-student interactions during the lesson. Throughout the three lessons the researcher observed in school 3 no student asked a question or make any remark and the teacher did not care to ask them any question. The instructional approach of the teacher is what Popham (2001) calls teaching to the test. The teacher focused his instructional and preparatory practices on the end of term examinations in December 2017 and the WAEC high-stakes examinations in May/June 2018. This showed that Teacher C used examination driven instructions during his lesson presentations.

### **Lesson observation: Teacher D**

Teacher D planned his lesson for the first visit on simple and compound interest. The teacher explained the concepts of simple and compound interest. He explained:

*Simple interest is calculated at the end of period of savings while in compound interest, the interest is calculated annually. The formula for simple interest is  $I = \frac{P \times T \times R}{100}$ , where  $P$  = principal,  $T$  = time pa and  $R$  = rate. Compound interest is  $A = P \left( 1 + \frac{r}{100} \right)^n$  where  $A$  = amount,  $P$  = principal,  $n$  = time and  $r$  = rate.*

The teacher solved some examples and gave the students some questions to solve in class. The classroom activities were structured in such a way that the students mostly apply memorized procedures and/or work routine exercises in mathematics. The teacher drilled the students on how to enter values into the formulae of simple interest, principal, time, rate and amount, and simplify to arrive at the correct answer. The teachers' knowledge of how the students think provides them with a framework that informs and guides them to understand, and to explain, how the students are making sense of mathematics. Classroom activities that are dominated by repetitive exercises or routine memorization or procedures are likely to limit meaningful learning Popham (2001, 2003, 2004) . The questions are in Figure 5.12.

- (1) Find the simple and compound interest of ~~R~~R890, 000 for 4 years at 20%
- (2) How much is earned for investing ~~R~~R537, 000 for 6 years at 10%

Figure 5.12: Examples solved by the teacher with the students on simple and compound interest.

Teacher D used blackboard illustrations and a textbook titled 'new general mathematics 3' for the lesson. His instructional and assessment practices focused on effective teaching and meaningful learning of mathematics but there were no classroom interactions. Students were passive listeners and copied the examples solved by the teacher on the blackboard. Schoenfeld clearly stated that in such instructional practices the student's reasoning is not actively engaged or pursued, and the teacher's actions are limited to corrective feedback or encouragement.

The lesson of the second visit to Teacher D was on depreciation. The teacher explained with examples the concept of depreciation as an item that loses value over a given period of time. He defined it as follows:

*Depreciation is the reduction in an asset's value or commodity value over time due to usage or abuse, wear and tear. Depreciation is calculated using the rate at which the commodity reduces in value multiply by the purchased price, which is, depreciating percentage time the cost price.*

The teacher solved two examples on the board. He asked:

Teacher: *Do you understand?*

Student: *Yes sir.*

Teacher: *What is the main idea on about depreciation?*

Student: *Depreciation is about loss of value after use. Moreover, we use percent to find that.*

Teacher: *Only? Can another person try?*

Student: *Depreciation is reduction in the value of commodity over time because tearing and wearing any of that commodity.*

Teacher: *Do you understand the definitions of the two students?*

Students: *Yes sir.*

Teacher: *Good, take note and solve these two questions.*

The teachers actively supported and engaged the students in whole class discussions and individual activities but did not allow groups discussion and student-student interactions. Figure 5.13 shows the questions solved as examples to the students.

1. A man bought a Toyota carina at ₦1, 500, 000 and sold it after 4 years at ₦900, 000. What is the rate at which the car depreciated?
2. A television was purchase at ₦25, 000, it depreciated by 20% annually. What was price of the television after 3 years?

Figure 5.13: Example questions on depreciation solved as examples to the students

In the case of Teacher D, he focused on students' understanding of important and relevant mathematical concepts, processes and relationships. He created an environment that helped students understand concepts that they were expected to learn, and the majority of the students were engaged in the lesson and they remained on task copying worked-out examples on the board. The cognitive demand of the tasks was moderate as all students responded by saying 'Yes sir' to the question about whether they understood the teacher's explanation. It is difficult to determine whether there was

equitable access to mathematics for all students from their choral responses given to the teacher's questions. It is evident that a whole class approach of choral answers could not be adequate for one to also say that there was students' contribution to development of agency, ownership over the content and positive identities as thinkers and learners of mathematics. However, the teacher used the lecture method, questioning, blackboard illustrations with examples on real-life situations and revision textbooks during the lesson.

The third lesson visit of the day was on trigonometrical ratios. The teacher explained the trigonometrical ratios with examples:

*For the trigonometrical ratios:  $\sin \theta = \frac{y}{r}$ ,  $\cos \theta = \frac{x}{r}$ ,  $\tan \theta = \frac{y}{x}$ , determines the values of the x- and y-coordinates and that the value of r is always positive.*

The teacher solved some example on method of finding numerical values of trigonometrical functions (e.g.  $\sin(180^\circ + \theta) = ?$ ) or  $y = a \cos x \pm b$  on the blackboard using four figure table and gave the students some questions to solve using the four-figure tables. And warned that

*Nobody should use a calculator of any kind because you will not be allowed to use it in the examination hall in June 2018, use a scientific calculator that is similar to the one WAEC will provide to you in the WASSCE.*

Figure 5.14 is the example solved with the students in the class.

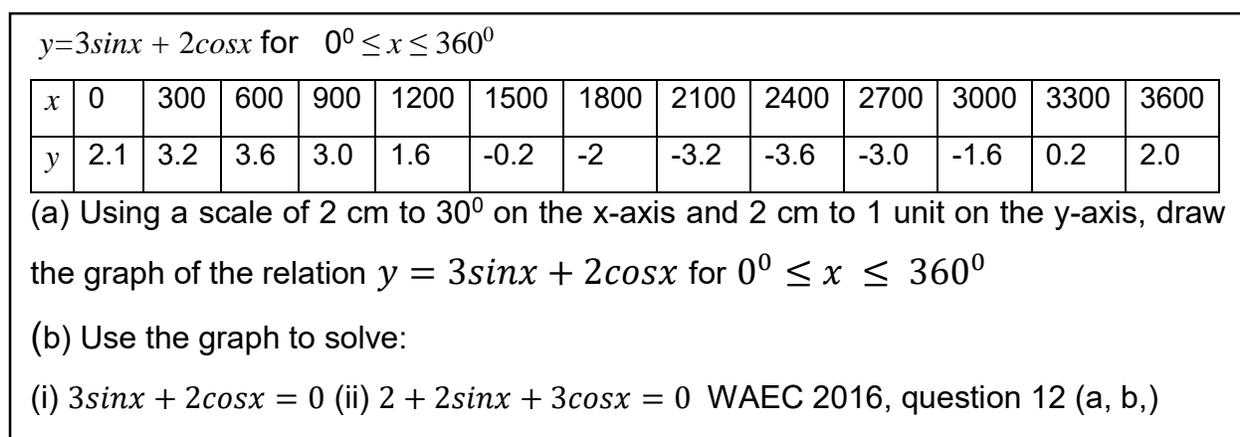


Figure 5. 4 Example of trigonometrical function solved with the students

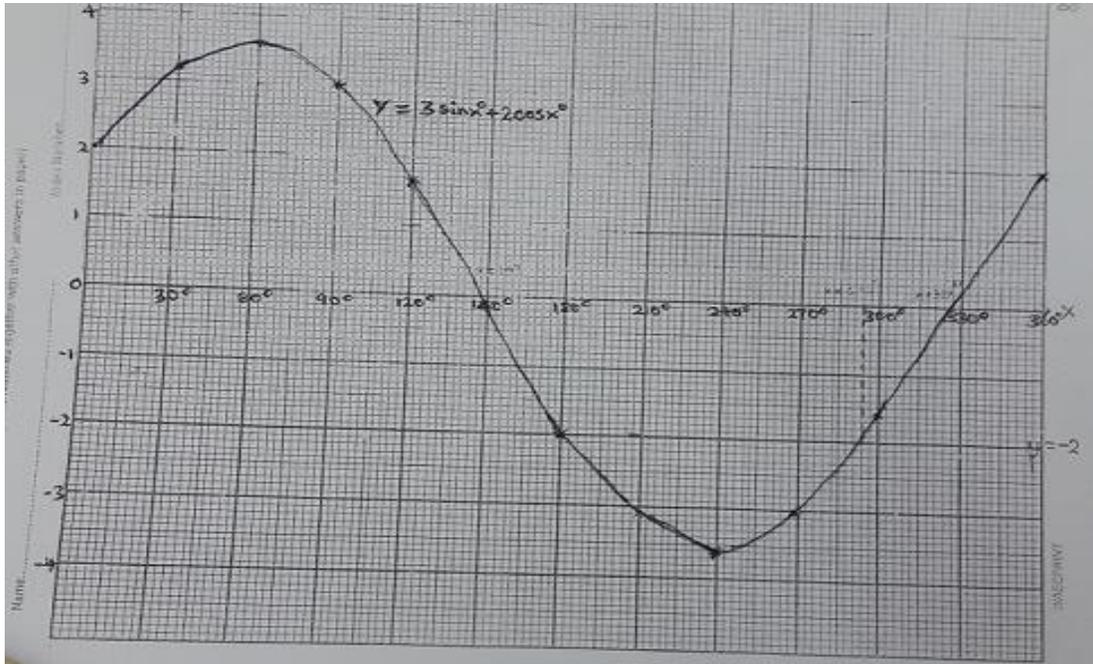


Figure 5.15: Graph of trigonometrical function solved with the students

Teacher D used blackboard illustrations, textbook, mathematical tables and calculator during the lesson. He focused on teaching procedure and meaning, understanding important and relevant mathematical concepts, processes, and relationships from past examinations question papers. The classroom activities took the form of examination-driven instruction. The majority of the students were engaged in the lesson and they remained on task busy copying and drawing the graph of  $y = 3\sin x + 2\cos x$ . According to Schoenfeld's (2016, 2017a, 2017b) framework of TRU, the issue here was the extent to which a learning environment provides students with the opportunities to develop their personal identities. Effective teachers recognize and capitalize on the strengths of each student, finding ways to help individual students enter into the learning. From an assessment practices point of view, it is clear that the item taken from WAEC past examination question papers showed the occasional use of examination-driven instructions for WAEC high-stakes examinations. However, these are opportunistic lessons that the researcher has observed; he does not know what happened in other lessons that were not observed.

**Lesson observation: Teacher E**

Teacher E's lesson for the first visit was on measures of central tendency (mean, median and mode). He employed the lecture method, WAEC past questions papers and a blackboard ruler for drawing frequency tables during instruction. The teacher defined the three terms with examples. He defined and explained,

*Mean is arithmetic average, that is, the sum of data values divided by the number of data set. When we arrange the data from the smallest to largest value, the middle data is the median. While mode is the data point with the largest frequency.*

The teacher solved a question on mean from the past examination question papers as examples, starting with how to present raw data in frequency tables and calculate the mean. The use of past examinations question papers showed how teacher E used examination-driven instruction and revision practice. On the one hand, instructional goals of instructional-driven instruction are clear, it is an effective way of improving the students' performance in high-stakes assessment and improving quality of education (Popham, 1987; Wayman, 2005). On the other hand, examination-driven instruction fragments knowledge, focuses on low level content, which frequently becomes the only content students are exposed to, leads to a loss of disciplinary coherence, mitigates against flexible knowing, contributes towards curriculum contraction by allocating an inordinate amount of time to test preparation, which leads to teacher stress. Figure 5.16 is the example of the frequency table and the calculation of mean.

The weight (in kg) of contestants at a competition is as follow:

65 66 67 66 64 66 65 63 65 68  
 64 62 66 64 67 65 64 66 65 67  
 65 67 66 64 65 64 66 65 64 65  
 66 65 64 65 63 63 67 65 63 64  
 66 64 68 65 63 65 64 67 66 64

(a) Construct a frequency table for the discrete data.  
 (b) Calculate, correct to 2 decimal places, the:  
 (i) Mean

Weight (x)	Frequency (f)	fx
62	1	62
63	5	315
64	12	768
65	14	910
66	10	660
67	6	402
68	2	136
	$\Sigma f = 50$	$\Sigma fx = 3,253$

$Mean = \frac{\Sigma fx}{\Sigma f} = ?$  WAEC 2016, question, 9(a)

Figure 5. 5: Example of the frequency table and the calculation of mean (WAEC, 2016, question 9 a).

The teacher did not solve the questions to the final answer. He always allowed the students to complete solving the remaining part of the questions. This is in line with Schoenfeld's (2017a) framework of teaching for robust understanding where he indicated the value of tasks that require students to think conceptually and to make connections leading to different sets of opportunities for thinking. The teacher encouraged students' productive struggle to complete examples solved in the class, which indicated that learning was not a matter of memorization, but one gets mathematics knowledge and skills by hard work. Most of the students completed the question as follows:

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f} = \frac{3253}{50} = 65.05 \text{kg}.$$

The students were able to substitute the sum of the values from the table to arrive at the correct mean value. The teacher told the class,

*I am not interested in the answer but your understanding of the procedure that will lead to the correct answer. If you understand the procedures in solving problems, I know you will arrive at the correct answer.*

The students were given a question to solve in the class. Therefore, the tasks and classroom activities framed by the teacher provided individual students with meaningful opportunities to practice mathematics and support their individual growth through active engagement with the content. Schoenfeld (2016, 2017a) explains that productive struggle is the mechanism for developing deep conceptual understanding of the mathematics content. Therefore, it is important for all students, not only for meaningful participation but for the students to engage with the content in ways that they come to own it and develop positive disciplinary identities. The best way to arrange for students to be working at the right level of challenge is to make their thinking publicly accessible, so that teacher's instructional and assessment practices can meet the students level of understanding in order to support their learning progress (see Table 3.2). However, there was no group work and whole class discussions by asking, clarifying questions and providing scaffolds. The teacher directly suggested ways to go about assigned tasks to the students

Teacher E focused on procedural knowledge of mathematics and meaningful learning, and emphasised high-stakes assessments and did revision practice using WAEC past examinations question papers. There was effective classroom management and control despite a large class size of 65 students. He could not get access to individual students because the classroom was very congested.

The lesson for the second visit was on continuation of measures of central tendency (mean, median and mode). The teacher marked the assignment given to the students in the previous lesson and solved the problems on the board for the students to do corrections. The teacher wrote down a question and said,

*Assuming a similar question is given to you during the next WASSCE in May/June 2018, how will you solve it?*

Nobody answered. Then the teacher asked,

*Can we solve it together?*

The students answered in chorus,

*Yes sir.*

The whole class approach of choral answers was an approval for the teacher to continue with the lesson. The teacher solved the question together with the students but allowed them to complete the final part of the question as usual (see Figure 5.17). He wrote 2016 May/June WASSCE, question 9 for the students to copy and practice. Such practice could be deliberate practice. Ericsson et al. (1993) contend that in deliberate practice the senior secondary school mathematics students are motivated to practise it, because it improves their performance in the classroom assessments and in high-stakes assessments. There was only teacher to whole class interaction, but not much meaningful contribution by the students, and hence very few opportunities for students to build on each other's understandings.

The frequency table below present the marks of students in a statistics examination:

Marks	15-24	25-34	35-54	55-64	64 and above
Frequency	15	20	30	15	20

Marks	Frequency (f)	Class mark (x)	Fx
15-24	15	19.5	292.5
25-34	20	29.5	590
35-54	30	39.5	1185
55-64	15	59.5	892,5
65-100	20	69.5	1390
	$\Sigma f = 100$		$\Sigma fx = 5740$

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f} = \frac{5740}{100} = 57.4 \text{ marks}$$

Figure 5. 6: Practice question on finding the mean

Teacher E focused on understanding important and relevant mathematical concepts, processes and relationships, and time was devoted to activities that emphasized high-stakes assessments and revision. There were no students' interactions; they were only engaged in copying and completing already solved questions in their exercise books. From an assessment practices point of view, the use of WAEC past examination question papers during instruction was intended to align teaching with high-stakes assessments. In line with Popham's (2001) instructional and assessment practices framework, it can be concluded that this was some form of teaching to the test in which the teacher anticipated the kind of questions of transforming raw data to frequency tables, solving problems of measures of central tendency as such can appear in future examinations.

The lesson for the third visit was on solving quadratic equations using a graphical method. The teacher explained that,

*In solving problems on quadratic equations, we can use factorization, method of completing the squares, quadratic equation formula or the graphical method. I will use the graphical method because they always ask this type of questions in the*

*external examinations and such questions demand more than just getting the factor or the roots of the equations.*

He further explained,

*To solve the equation  $ax^2 + bx = 0$  graphically, you plot the points on a table, transfer the coordinate points into the scaled graph, join the points and read off the values where the graph of  $ax^2 + bx + c = 0$  intersects the x-axis, because on the x-axis all the values of  $y = 0$ .*

The teacher also explained some situations that may arise,

*If the quadratic equation has two roots, the graph of the equation intersects the x-axis in two places. One root can be written as a perfect square  $(\dots)^2$ , the graph  $ax^2 + bx + c = 0$  intersects the x-axis in only one point or just touches the x-axis. No real roots, the graph of the equation does not intersect the x-axis at all.*

The teacher then solved one question using the mathematical instruments. The students were asked to copy the table and draw the graph on their graph sheet. The pedagogy applied by the teacher was of illustrating the procedures on the chalkboard, and then explaining to the students how to practise the procedures. The teacher just explained and solved the questions on the board without calling for student input, whether right or not. The students were not provided with meaningful opportunities for learning that support their growth through active engagement with the content. He gave the students assignments at the end of the lesson. The assignment question appears in Figure 5.18.

The table is for the relation  $y = px^2 - 5x + q$

$x$	-3	-2	-1	0	1	2	3	4	5
$y$	21	6	-5	-12	-15	-14	-9	0	13

(a) (i) Use the table to find the value of  $p$  and  $q$ .

(ii) Copy and complete the table.

(b) Using the scale 2 cm to 1 unit on the x-axis 2 cm to 5 units on the y-axis, draw the graph of the for  $-3 \leq x \leq 5$ .

(c) Use the graph to find:

(d)  $y$  when  $x = 1.8$ ;  
 $x$  when  $y = -8$ .

y

Figure 5. 7: Assignment question on quadratic equation Graph (WAEC 2015, question 7a, b, c)

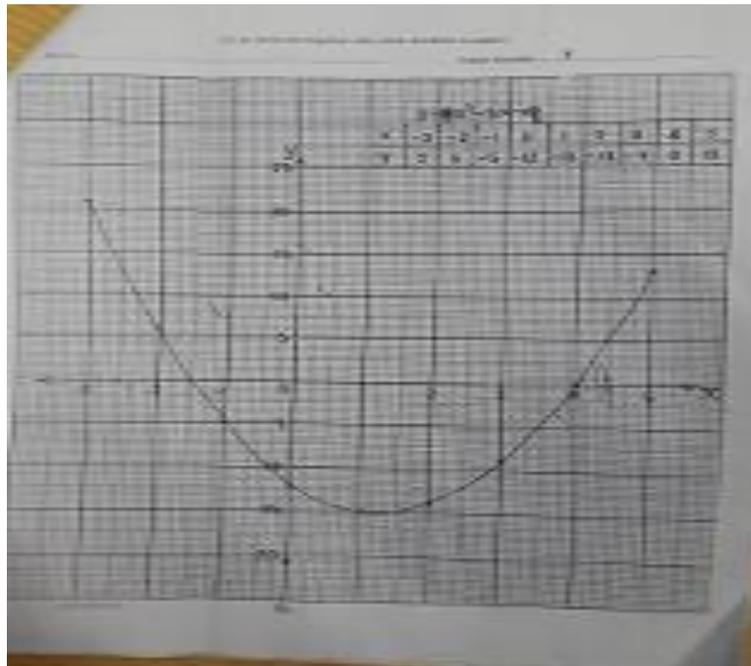


Figure 5. 8: Graph on quadratic equation  $y = px^2 - 5x + q$

Teacher E focused on understanding important and relevant mathematical concepts, processes and relationships, and time was devoted to activities that emphasized high-stakes assessments and revision. There were no student interactions; they were only engaged in copying the solved questions in their exercise books. The Chief Examiner reported how students make mistakes in solving mathematics problems during examinations (see section 1.4.6.2). In the report it was suggested that candidates should be led to acquire knowledge of various mathematical concepts and how to apply them to solving problems in everyday living. It can be assumed from the teacher's presentation of the lesson that his pedagogical belief is that students passively receive knowledge from the teacher. More importantly, the instructional practices reflected characteristics that imply that teaching mathematics involves showing and telling, with the teacher simply explaining and illustrating the procedure for solving mathematics problems on the board for students to copy and practise. The instructional and assessment approach was also influenced by the WAEC high-stakes examinations.

#### **Lesson observation: Teacher F**

Teacher F prepared his first visit lesson on ratio and adopted the lecture method. The teacher defined and explained the concept of ratio using real-life situations and later solved some examples from the textbook he was using. He explained,

*You can recall that to express  $\text{R}25,000 : \text{R}15,000 : \text{R}10,000$  in its lowest ratio is  $5:3:2$ , since  $\text{R}5,000$  is the common factor of the three values. If John, Peter and Samson shared  $\text{R}1050$  in ratio  $6:7:8$ , what will be Samson's share? To solve this, we first get the sum of the ratio  $6+7+8 = 21$ , and then Samson's share is  $\frac{8}{21} \times \text{R}1050 = \text{R}400$ .*

After solving some questions with the students, he told them to take note of the procedures used in solving problems relating to ratio. The students were insufficiently challenged and engaged during instruction. The students were taught to have knowledge of solution procedures that can be applied during high-stakes examinations but this deprived the students of meaningful learning that Schoenfeld (2016, 2017a, 2017b) described as the TRU framework (see subsection 3.2.2). According to Schoenfeld,

learning is enhanced when the teacher attends to students' thinking and the instructional practices are adjusted so that students engage with the content at a productive level of cognitive demand.

The lesson for the second visit was on profit and loss. The teacher used the lecture method and questioning techniques, was textbook-bound and not student-centred in his instructional and assessment practices. He explained the meaning of the two concepts with examples. He defined and explained,

*Profit is the amount of money gained in buying and selling of goods or commodities and when those goods or commodities are sold at prices less than the cost price it is a loss. In business you either expect profit or loss.*

The teacher explained with examples how to find profit or loss and their percentages.

The teacher commented that:

*Those business men and women you see buying and selling goods always strive to maximize profit from those goods they purchase. They use these methods to determine whether they have profit or loss from the goods they sold out. The knowledge acquired from this topic can help you attempt similar questions in the examinations and you also use it in your business or help someone in any business.*

At the end of the lesson the students were given a take-home assignment (see Figure 5.20).

A television set was marked for sale at GH¢760.00 in order to make a profit of 20%. The television set was actually sold at a discount of 5%. Calculate, correct to 2 significant figures, the actual percentage profit.

Figure 5.9: Assignment on profit and loss (WAEC 2014, question 6b)

According to Popham's (2001, 2003, 2004) framework, what counts in mathematics teachers' instructional practices is what the students learn – their conceptual understanding of mathematics. Examination-driven instruction fragments knowledge

presented by the teacher into low-level cognitive domains, which frequently become the only content students are exposed to and leads to a loss of disciplinary coherence and militates against flexible conceptual understanding. In preparing students for high-stakes examinations the process has a chance of success or failure depending on the teachers' instructional practices. Teachers need to use their MKfT (Ball et al., 2008; Hill & Ball, 2009) wisely by teaching students knowledge and skills that enhance the prospects for students' success in their examinations.

The lesson third visit was on simple and compound interest. He introduced the lesson by explaining the difference between simple and compound interest. He said

*Simple interest is the money earned for saving or lending out money for a period of time and at a particular rate while in the compound interest the interest gain is cumulative. The simple and compound interest on a given principal at a given rate over a given period of time. We use simple interest formula,  $I = \frac{PxTxR}{100}$  to calculate the interest  $I$  if a principal  $P$  is invested for  $T$  years at  $R$  % per annum. We use the compound interest formula,  $A = P \left(1 + \frac{r}{100}\right)^n$ , where  $A$  is the amount and  $P$  is the principal invested for  $n$  years at  $r$  % per annum.*

The teacher solved some questions for the students as examples from the textbook he was using and from some WAEC past question papers. Two of the questions appear in Figure 5.21.

1. A sum of ~~N~~4000 invested at a rate of 5%. What was the compound interest at the end 20 years?
2. Peter invested ~~N~~10000 for 6 years at 9%. What was his amount at the end, using compound interest?

Figure 5. 10: Two of the example questions on simple and compound interest

The teacher used the traditional teacher-centred method, a calculator, a textbook and some WAEC past question papers. This mean the lesson was illustrative of the teachers' revision practice as the WAEC high-stakes mathematics examinations were fast approaching. The concepts and procedures in solving compound interest were explained

to the students. The important attached to the senior secondary school students' performance influences the teacher's instructional practices and made them focus their instructional practices on preparing the students for the WAEC high-stakes examinations in May/June 2018.

### **Lesson observation: Teacher G**

The lesson for the first visit was on quadratic equations - completing the squares. The teacher used the lecture method in his instructional approach. He explained,

*A quadratic equation is an algebraic equation with a mathematical phrase that contains ordinary numbers, variables (such as  $x$ ,  $y$  or  $c$ ) and operators (such as add, subtract, multiply, and divide). For example,  $x^2 + 8x + 16 = 0$ . The equation can be factorised as  $(x + 4)^2$ .*

He further explained that to factorise a quadratic equation, one can use direct factorization, completing the squares or using the quadratic formula but depending on the nature of the equation. He said,

*But today we are using completing the squares method. For example, solve the quadratic equation  $x^2 + 18x + c = 0$ . To find  $c$ , half of the coefficient of  $x$  will be 9 and squared as  $(9)^2 = 81$  for the equation to become  $x^2 + 18x + 81 = 0$  where  $c = 81$ .*

The teacher then said to the students,

*These are the types of questions you will get in WAEC or NECO examinations.*

The students were given some questions to solve using the examples in the classroom (see Figure 5.22).

- (1) Find  $b$ , if  $x^2 + 24x + b = 0$   
 (2) Find  $c$ , if  $2x^2 + x + c = 0$

Figure 5. 11 Quadratic equations solved by the students

The students learnt the concepts of square, perfect square and how to factorise quadratic equations by the method of completing the square. The teacher used the traditional teacher-centred method and questions directly from a general mathematics revision textbook. The classroom activities were structured in such a way that the students mostly applied procedures and/or worked out routine exercises in mathematics. The teacher drilled the students on how to factorise quadratic equations using completing the square. The teacher's knowledge of how the students think provides mathematics teachers with a framework that informs and guides them to understand, and to explain how the students are making sense of mathematics. The teacher emphasised the WAEC high-stakes examinations to the students.

The topic for the second visit was on evaluation of logarithms. Teacher G started the lesson by giving the definition of "logarithm", "antilogarithm", explained with examples. He said,

*Logarithm of a number is the exponent or power to another fixed value, the base, must be raised to produce that number. For example, the logarithm of 1 000 to base 10 is 3, because 10 to the power 3 is 1 000:  $1\ 000 = 10 \times 10 \times 10 = 10^3$ . That is,  $\log_{10} 10^3 = 3 \log_{10} 10 = 3 \times 1 = 3$  (log of the base is one). Now the antilogarithm is the number of which a given number is the logarithm. For example, the antilogarithm of 3, if the base was 10 is 1 000.*

He said,

*Now, let me give you a WAEC question as an example.*

He wrote on the board,

Evaluate  $\frac{82.47 \times 24.85}{299.3}$  "evaluate means to determine the number value of something or find the answer.

He said:

*Now get out your logarithms table and let us work this together.*

All the students except one had four-figure tables, but Teacher G managed to solve the question given. After solving the examples, he then gave the students three questions to solve. The questions were similar to that in Figure 5.6, above (Teacher B's lesson on Logarithms).

The teacher placed more emphasis on WAEC high-stakes examinations in his lesson and his work with the students was an outline procedure of the WAEC WASSCE marking scheme. He taught logarithms of numbers greater and less than zero within one lesson because he was working against time. The students were in class without mathematical tables and the teacher did not have one to use, never mind supplying to the students. The teacher had used technical language in explaining how to find the characteristic of any given number in his worked examples. (Schoenfeld, 1992, 2016, 2017a, 2017b). Schoenfeld (2011) refers to mathematics teacher knowledge as a very precious intellectual resource. This mathematics teacher's knowledge influences goal-setting performance and persistence of effort and effective teachers' instructional and assessment practices in the school system. Hence, teacher G managed to explain that:

*To find the characteristic of a number, we use the knowledge of standard notation form or one less than the number of the whole numbers.*

Teacher G used traditional methods, blackboard illustrations, and a revision textbook for WAEC/NECO. The students were engaged but had limited resources (there were no mathematical tables).

The lesson for the third cycle was on statistics – bar charts and pie charts. After writing the topic on the board the teacher said:

*I want you to pay attention to this topic because it always appears in WAEC or NECO. Bring out your mathematical instruments and your graph books so that we start in earnest.*

He defined and explains bar chart and pie chart:

*A bar chart is a diagram with bars proportional to the quantities they represent and there are equal gaps in between bars while a pie chart is a circular diagram in*

*which the sectors are proportional to the quantity they represent. In a pie chart, the angle of each sector is in the same ratio as the quantity the sector represent.*

The teacher used data from some WAEC past questions and from the textbook he was using to work out the examples for the students. He drew the bar charts using a ruler and the pie charts using a ruler, a pair of compasses and a protractor. The students were given an assignment on the lesson taught.

Below are marks obtained by students in a statistics examination:

Marks	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Frequency	2	3	5	13	19	31	13	9	4	1

(a) Draw a bar chart to represent the marks obtained by the students.  
 (b) If 60% pass the statistics examination, how many students pass?  
 (c) What is the probability of those who pass?

Figure 5.23: The assignment given to the students on statistics.

(a)

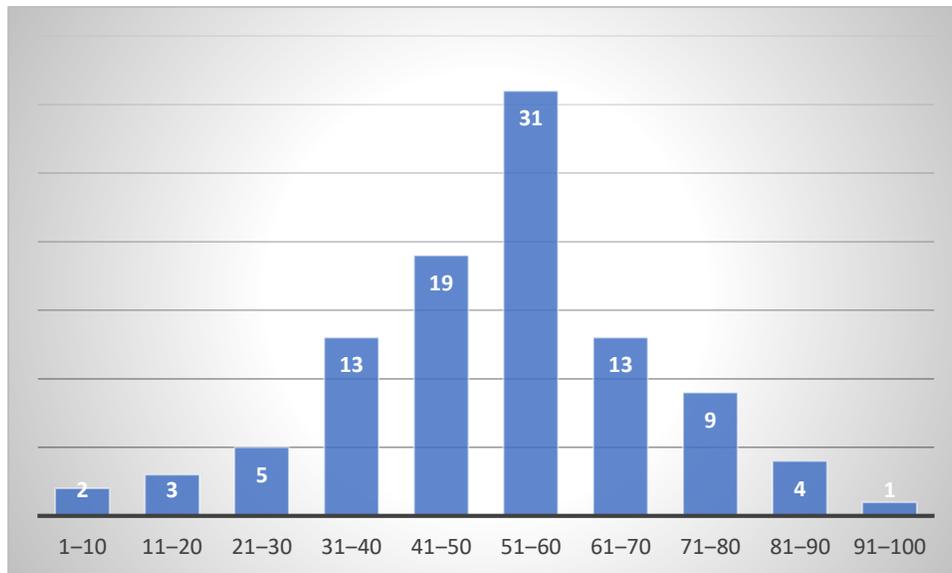


Figure 5.24: The bar chart representing students' marks in statistics examination.

(b) The number of students that pass are  $\frac{60}{100} \times 90 = 54$  students.

(c) The probability of the students that pass is  $\frac{54}{90} = 0.6$

Teacher G rushed to finish the topic because he was working with limited time to cover much from the scheme of work before the WASSCE high-stakes examinations began in May/June 2018. There was no graph board for drawing of the bar charts and the pie charts, the teacher followed the construction step-by-step for students' understanding and the construction was shown on the white board used. According to the frameworks for this study, high-takes assessments need to be aligned with the desired outcomes of instruction practices. If instructional practices focus only on skills and procedures to be used in high-stakes assessments, they may likely fail to demonstrate students' problem-solving skills (Schoenfeld, 2016, 2017a, 2017b). However, well aligned instructional practices that focus on a specific body of mathematics content knowledge or specific cognitive skills represented by high-stakes examination items (Popham, 2001) may make students develop ownership over content and positive identities as thinkers and learners (Schoenfeld, 2016).

#### **Lesson observation: Teacher H**

Teacher H planned his first visit lesson on simple and compound interest. The teacher used the lecture method in his instructional approach. The lesson was a continuation of the previous lesson. The teacher revised the work on simple interest taught in the previous lesson. He then emphasized:

*During WAEC or NECO examinations don't forget to write down the formula before substituting the values and simplify to get the final answer.*

He then continued with the teaching of compound interest. He said,

*Remember that simple interest is calculated at the end of a period of savings. But for compound interest, the interest is calculated based on the amount saved for a period of time and at a particular rate, and the interest is added to the principal to earn interest for the follow year. Compound interest is calculated cumulatively to the end of the period of savings.*

The teacher used WAEC past questions as examples and gave the students some questions to solve in class (see Figure 5.25).

- (1) A man deposited ₦84,000.00 for  $2\frac{2}{3}$  years at 5% simple and compound interest.
- (2) A principal ₦5,600.00 was deposited for 3 years at compound interest. If the interest earned was ₦1,200.00, find, correct to 3 significant figures, the interest per annum. WAEC 2016, question 1(b)

Figure 5.12: Classwork questions on simple and compound interest (WAEC 2016, question 1b)

Teacher H went to the class with a piece of paper containing written past questions from WAEC high-stakes examinations. His instructional and assessment practices focused on preparatory and revision practices for high-stakes examinations coming up in May/June 2018. However, he used traditional teacher-centred methods and applied examination-driven instruction.

The lesson for the second visit was on investment and annuity. The teacher revised the previous class work with the students and continued with the lesson and introduced the new topic. He explained:

*Annuity calculation is similar to the calculation of compound interest, except that the period of investment reduces continuously as time pass by, that is, annuity is calculated when money is invested for future use. It is usually a way to save for retirement. So, the retirement schemes we have in Nigeria are expected to use annuity in calculating their customers' investment. Therefore, the value or interest of somebody's investment is compounded daily, monthly or annually.*

He then gave examples and said,

*In calculating annuity we can use depreciating value formula,  $A = P(1 + i)^n$  where  $A$  is the depreciated value,  $P$  = present value,  $i$  is the rate of depreciation per year or  $\frac{r}{100}$  and  $n$  = time in years or we can use the formula for finding the sum of geometric series  $S_n = \frac{a(r^n - 1)}{r - 1}$   $a$  is amount invested annually,  $r$  is the rate and the  $n$  is the number of years.*

The teacher solved examples using the two formulae and gave the students an assignment (see Figure 5.26).

Johnson pays ~~R~~40 000 per year to save for his retirement. He pays this amount at the end of each year for 30 years at 12%. Using the annuity formula, how much will he earn at the end of the 30th year?

Figure 5.13: An assignment question on calculating annuity

One of the students asked:

Student: *In calculating the annuity why are the value of the power  $n$  reducing to zero instead of starting from zero to  $n$ ?*

The teacher replied her,

Teacher: *Remember that the number of years the customer agreed upon continuously pass by. For example, investment for 20 years, when the first-year pass, remain 29 years and the years will be reducing to zero year. The customer does not give a fixed amount for the  $n$  years but rather contribute the fixed amount annually.*

Teacher: *Do you understand?*

Student: *Yes sir.*

He was to continue with the topic the next lesson in order to complete teaching the topic. The teacher's lesson was over and he had to allow another teacher to enter for the next lesson. The teachers actively supported the student to clear the confusion on how to calculate annuity, which was a sign of classroom discourse between the teacher and the students. This is in line with Schoenfeld's (2016, 2017a) recommendations that teachers in their instructional practices should actively support their students in individual work, group work, and whole class discussions by asking clarifying questions and providing scaffolds, instead of moving directly to suggesting specific ways of solving assigned tasks.

Teacher H used the traditional method, blackboard illustrations, textbooks and past questions papers. He focused on understanding important and relevant mathematical concepts, processes, and relationships, encouraged the students to think beyond the immediate problem and make connections to other related mathematical concepts and assessed and connected students' understandings.

The lesson for the third visit was a continuation of investment and annuity. The teacher practised WAEC and NECO past questions with the students and gave them some take-home assignment questions to practice. The methods applied by the teacher in the lesson were revision practice for high-stakes examinations or examination-driven instructions (Julie (2013a)). Julie (2013a) observed that no matter what the disadvantages of examination-driven instruction are, teachers' instructional practices will always be driven by high-stakes assessments. The use of past WAEC examination question papers and the emphasis by the Teacher H on WAEC's WASSCE showed how WAEC high-stakes examinations influence the teachers' instructional and assessment practices.

### **Lesson observation: Teacher I**

Indices and logarithms were the topics of the first visit for Teacher I. The teacher used the lecture methods, a lesson notes book and textbook during instruction. The teacher solved the questions on the assignment given to the students in the previous lesson for the students to take correction. He then explained how indices and logarithms are related. He explained that

*If  $a^x = y$  is the exponential form, then  $\log_a y = x$  is the logarithmic form. Provided  $a > 0$ ;  $a \neq 1$ ;  $x > 0$ ;  $x$  and  $y \in \mathbb{R}$ . For example, index equation  $2^3 = 8$  as an equivalent logarithm equation,  $\log_2 8 = 3$ .*

The students were confused when the exponential form was written in logarithmic form because the logarithm is not in base 10. He further revised the laws of indices and logarithms:

$$2^5 \times 2^3 = 2^{5+3} = 2^8, 2^5 \div 2^3 = 2^{5-3} = 2^2 \text{ and } ((2)^4)^2 = 2^{4 \times 2} = 2^8 \text{ while } \log_2 5 + \log_2 3 = \log_2 5 \times 3 = \log_2 15, \log_2 16 \div \log_2 4 = \log_2 \frac{16}{4} = 2 \log_2 2, \log_2 8 = \log_2 2^3 = 3 \log_2 2 = 3 \times 1 = 3.$$

After these explanations, the teacher then called on one of the girls in class to solve one of the problems on the board. The problem the girl solved together with her classmate is below in Figure 5.27.

Solve  $\log_5 625$  .

$$\log_5 625 = \log_5 5^4 = 4 \log_5 5 = 4 \times 1 = 4$$

Figure 5.14: The question solved by a student on the board

Teachers can actively support students in individual work, group work, and whole class discussions by asking clarifying questions and providing scaffolds, instead of moving directly to suggesting overly specific ways to go about assigning tasks to the students. The teacher then gave the students some class work. He was then going around marking and correcting students' work. The students followed the worked examples to complete the classwork. The theoretical frameworks of Popham (2001, 2003) and Schoenfeld (2016, 2017a) suggest that teachers can use a variety of instructional strategies to encourage broad participation of students in the lesson, like choosing to call only on students who have not yet spoken; allowing time to talk to a partner before responding publicly; and randomly selecting the students to contribute to the lesson. Teacher I's instructional practices were also similar to the fourth dimension described by Schoenfeld (2016, 2017a).. Schoenfeld's (2016, 2017a) emphasized that a powerful mathematics classroom instruction is the one that students have the opportunity to generate and share ideas, both in whole class and small groups. The extent to which student ideas are built upon depends on the way that the classroom teacher constructs its collective understandings by making students develop positive identities as thinkers and learners. The teacher then gave the students some class work.

The teacher assessed and connected the students' understanding of indices and logarithms. He articulated what mathematical ideas and/or procedures students were expected to learn and make sense of mathematics as encouraged by Schoenfeld (2016, 2017a). Popham (2001, 2003) also encouraged teachers on the important of the five attributes of an instructionally useful test: its significance, teachability, describability, reportability and non-intrusiveness. These perspectives are important for a day-to-day effective teaching and meaningful learning of mathematics.

Teacher I's topic for the second lesson visit was on application of linear and quadratic equations. The teacher explained the difference between linear and quadratic equations with examples.

*A linear equation is an equation which highest power of the variable as one, for example,  $ax + b = 0$ . While a quadratic equation is polynomial in which two is the highest power of the variable, for example,  $ax^2 + bx + c = 0$ . In the application of linear equations, we transform word problems into linear equations that may be solved algebraically. Likewise, in the application of quadratic equations we transform word problems into quadratic equations that may be solved algebraically. Let us concentrate on quadratic equations because that is where WAEC mostly asked their questions in the WASSCE. To solve quadratic equations one can use factorization, completing the square, quadratic equation formula or the graphical method.*

He added,

*For this lesson we are using the graphical method.*

After working through some examples using graphical methods, he gave them one question from the WASSCE to solve in the class, but none of them was able complete the classwork within the lesson time. They were asked to complete the work at home and bring it for marking the following day.

Teacher I used the traditional teacher-centred method, blackboard illustrations, a textbook, WAEC past questions papers and blackboard mathematical instruments. He

managed to draw the graph using the plain blackboard because there was no graph board in the school. The students had their mathematical instruments and were able to draw the graph as instructed by the teacher.

Teacher I continued with the topic of the previous lesson (quadratic equations) and he was unable to finish during the third visit. He moved round the classroom marking and correcting the students' work and later worked out the question on the board for the students to make corrections. He then practised more questions on quadratic equations.

Students were allowed to discuss the question among themselves. The majority of the students were engaged in the lesson and remained on task. Students willingly and openly discussed their thinking and reasoning (see Figure 5.23). Teacher I's pedagogical practices were also similar to the fourth dimension of Schoenfeld framework of powerful mathematics classroom where students have the opportunity to generate and share ideas in the whole class. However, the teacher still emphasized areas on which WAEC high-stakes examinations often set their questions.

### **Lesson observation: Teacher J**

Teacher J's lesson for the first visit was on simple and compound interest. This topic was also taught by Teachers D and H. His approach to the teaching was similar. He explained the concepts of simple interest and compound interest and solved some examples. He explained:

*Simple interest is the amount gained for saving money at a particular rate and at period of time. Formula for simple interest is  $I = \frac{P \times T \times R}{100}$  where  $I$  is interest,  $P$  is principal,  $T$  is period of savings and  $R$  % is rate per annum. In compound interest, the interest of the first year is added to the principal, so is the second year cumulatively to the end of the period of savings. Our banks use compound in interest in calculating their customers' interest. The formula for calculating compound interest is  $A = P \left(1 + \frac{r}{100}\right)^n$ , where  $A$  is the amount,  $P$  is the principal,  $n$  is the years invested and  $r$  % is rate per annum.*

The teacher solved some examples together with the students. He gave the students some class work and moved around checking and correcting students' work. After the class activities, the students were given a take home assignment (see Figure 5.28).

1. What the simple and compound interest for saving ~~R~~87,450 for 6 years at 10%?
2. How much should be deposited now if we require ~~R~~50,000 at the end of 15 years at 5%?

Figure 15: Assignment questions on simple and compound interest

The Teacher J used lesson notes, a textbook and WAEC/NECO past question papers for his examination-driven instruction and revision practice. The teachers focus on teaching procedure, explaining the procedure and teaching to the test.

The lesson for the second visit was on exponents (laws of indices). The teacher explained meaning of indices with examples and list the laws of indices with examples. He explained,

*Indices are exponential or power numbers such as  $2^3 = 2 \times 2 \times 2$  or  $a^4 = axaxaxa$ . The laws of indices are: the first law: is  $a^x \times a^y = a^{x+y}$ , the second law is  $a^x \div a^y = a^{x-y}$  and the third law is  $((a)^x)^y = a^{xy}$ . Other laws are  $a^1 = a$ ,  $a^0 = 1$ ,  $a^{-n} = \frac{1}{a^n}$ ,  $a^{1/n} = \sqrt[n]{a}$  and  $\sqrt[n]{a^n} = \begin{cases} a, & n \text{ odd} \\ |a|, & n \text{ even} \end{cases}$ .*

After solving some examples, the teacher gave the students some questions from the lesson notes to solve in the class. He later added more questions for the students as a take-home assignment (see Figure 5.29). This topic was also taught by Teacher I. The teacher exhibited CCK in the teaching of indices as the concepts and practices of the topic were presented to the student to grapple with and make sense of mathematics in the class.

Solve the following log. Without using tables:

$$(1) \sqrt[3]{64} = 4 \quad \sqrt[3]{64} = 4 \text{ or } \sqrt[3]{64} = ((4)^{1/3})^3 = 4$$

$$(2) \left(\frac{27}{125}\right)^{2/3} = \frac{27^{2/3}}{125^{2/3}} = \frac{3^2}{5^2} = \frac{9}{25} \text{ or } \left(\frac{27}{125}\right)^{2/3} = \frac{\sqrt[3]{27^2}}{\sqrt[3]{125^2}} = \frac{3^2}{5^2} = \frac{9}{25}$$

Figure 5. 16: Assignment on how to solve problems in indices using different methods

The teacher used the difference methods of solving problems in indices. He told the students,

*Therefore, there are various ways of solving problems in indices. In examination, used the method that will give you the shortest possible solution. You know you will work with time during examination. The examples I gave you should be an eye opener.*

Teacher used traditional teacher-centred method, blackboard illustrations, textbook on WAEC past questions papers. He focused on understanding important and relevant mathematical concepts, processes and relationships. He was able to connect the mathematical ideas and/or procedures that students were expected to learn, and more emphasis was placed on the WAEC high-stakes examinations.

Teacher J continued with the students in teaching and learning of indices during the third visit. He marked the students' work and solved the previous class work and the take-home assignment with the students. The routine instructional and assessment practices of the teacher were organized around self-contained classroom, whole group, textbook-bound instruction, teaching as telling, learning as the passive acquisition of facts and entirely focusing on high-stakes assessments. The teacher could not use learner-centred approaches because he was rushing to cover the syllabus and prepare the students for the WASSCE. Most of these practices were therefore instances of Popham's (2001) teaching to the test and negated Schoenfeld (2016, 2017a, 2017b) framework of teaching for robust understandings.

## Summary of lesson observations

The topics, instructional materials and method of assessment of the participants (Teacher A to J) is summarised in Table 5.5.

Table 5. 5 Summary of lesson observations

Participant	Topic	Instructional materials	Assessment
Teacher A	Modular arithmetic, Direct & inverse variation and Joint variation	Lesson notes book	Questioning, assignment & practice of WAEC/NECO question papers
Teacher B	Logarithms, matrices & surds	Textbook & mathematics tables	Questioning, classwork & assignment
Teacher C	Simultaneous linear equations & Revision	Textbook & a file containing WAEC/NECO past questions papers	Questioning
Teacher D	Simple & compound interest, depreciation & Trigonometric ratio	Textbooks, calculator & mathematical table	Questioning, classwork & assignment
Teacher E	Measure of central tendency & Quadratic equations	Textbooks, WAEC/NECO past questions papers & ruler	Questioning, classwork & assignment
Teacher F	Ratio, Profit & loss and Simple & compound	Textbooks, WAEC questions papers & calculator	Questioning & assignment
Teacher G	Quadratic equations, Logarithms & statistics (bar & pie charts)	Revision textbook & mathematical instruments	Questioning classwork & assignment
Teacher H	Simple & compound interest, Investment & annuity//revision	Textbooks, WAEC/NECO past questions papers & calculator	Questioning, Classwork & assignment
Teacher I	Indices & logarithms and Linear & quadratic equations	Textbooks & WAEC past questions papers	Questioning, classwork & assignment
Teacher J	Simple & compound interest, Indices	Textbook and WAEC past questions papers	Questioning, classwork & assignment

In the general analysis from the three lesson observation visits, four out of the ten participants did not present their lesson plans, but filled the lesson preparation forms (see Appendix D). The researcher was more interested in his lesson preparation form than the lesson plan. From the few that presented their lesson plans and filled the lesson preparation forms (see Appendix D), what was prepared was not exactly what that was fully presented during instruction. However, the responses from the lesson preparation form were well structured (see Appendix D). The dominant teaching methods were whole class instruction, individual learning strategies, traditional method (lecture-based, teacher-centred and textbooks-bound) and few examples linking to real-life events. The participants used *New General Mathematics 3* textbook and other revision textbooks on

high-stakes examinations, WAEC/NECO high-stakes examinations past question papers, and a few used lessons note books, mathematical instruments, mathematical tables and calculators. The participants' instructional practices involved hurrying to cover a great number of topics through lectures and coaching before the start of WAEC high-stakes examination in May/June 2018 without engaging the students in meaningful learning. This undermines Schoenfeld's (2017a) framework of TRU, where the teachers were supposed to teach the students for conceptual understanding and not for unsystematic preparation for WAEC high-stakes examinations.

Senior secondary school 3 (SSS3 students) is a graduating class for Nigerian secondary education and teachers are expected to prepare the students for the May/June WASSCE in mathematics annually. Teachers teaching the SSS3 students are supposed to prepare them for the examinations but in the appropriate way. Teachers in this study were observed unsystematically drilling and coaching students to memorize solution procedures and rushing to cover curriculum content they thought had a high likelihood of being tested in the WAEC high-stakes examinations. The Nigerian senior secondary school mathematics teachers in their preparatory practices are supposed to teach for conceptual understanding and equitable access to legitimate mathematical knowledge and share multiple solution strategies. Teachers rarely talk about curriculum demands in their instructional practices with the use of past examination question papers and revision textbooks. This is because some authors have aligned the content of the mathematics curriculum with past examination question papers to produce their textbooks

The classroom questioning techniques were either content-based, process-based or both and the teacher-student interaction in the classroom was not encouraging (see the teacher A to J transcripts in Appendix G). The assessment strategies employed were showing and telling, with the teachers' simply explaining and illustrating procedures for solving problems in mathematics on the board for students to copy and later do classwork/assignments. There were no provisions for students' group work, student-student interaction and collaboration in their classroom instructional practices. However, it could be possible that they still believed that the teacher's role remains that of explainer, transmitter of knowledge and most considered getting correct answers to be the most

important goal in mathematics instructional and assessment practices. These instructional practices were influenced by the Kaduna State senior secondary school mathematics teachers' views and beliefs about what it means to teach mathematics effectively which was therefore different from those advocated by Popham's teaching to the curriculum and conceptual understanding, Schoenfeld's TRU in mathematics, and the recommended distribution of Bloom's taxonomy of educational objectives. Although these frameworks are constructivists views, their recommendations about how mathematics should be taught make a difference when teachers adhere to their principles and practices.

Teachers conducted their continuous assessments (CA) tests individually and at their convenience. From the researcher's observations the class work, assignments and tests in mathematics form the CA of the term. The class work and assignments made up 15% and the tests constituted 15% making a total 30% of part of the 100% total scores in the term examinations. The schools conducted their first-term examinations between the last week of November and first two weeks of December 2017. The 70% score from the term examination was added to the 30% CA to make a total of 100% following the prescribed ratio of 15:15:70. The researcher also confirmed how the CA is calculated cumulatively from SSS1 to SSS3 (see section 2.15 and 5.6).

As mentioned earlier, the participants' instructional, preparatory and assessment practices reflected characteristics that imply that teaching mathematics involves showing and telling, with the teachers simply explaining and illustrating on the board for students to copy and later do classwork/assignments. Additionally, the mathematics instructional practices at the senior secondary schools observed was to get WAEC past questions papers and other revision textbooks, and hurry to drill and coach the students to be successful in the WAEC high-stakes examinations regardless of their students' conceptual understanding of the mathematical concepts taught. In the case of SMK (see Figure 2.3), the teachers had the common content knowledge (CCK) but it was difficult to determine their specialized content knowledge (SCK) and knowledge at the mathematical horizon (or horizon content knowledge) (Ball et al., 2008).

In all the instances of Teachers A to J (a) their lessons were illustrative of the teachers' regular instructional practices closer to the high-stakes assessments; (b) the lesson content presented was opportunistic in the sense that these lessons were the ones the researcher found at the time he visited individual school; (c) the lesson content/topics count for quite a lot of marks in the high-stakes assessment, hence the teachers focused on them; (d) the lesson content had conceptual and procedural challenges which were mentioned in the Chief Examiner's reports (see section 1.4.6.3.1); (e) the researcher could only visit each of the ten participating school five time because of transportation/distance issues. The first visits were the initial visits, the next three visits were for the proper lesson observations and the last visits were for teachers' interviews (see section 5.4, 5.5 and 5.6.2).

### **5.6.2 Final lesson observations**

The researcher used the final lesson observations in January 2018 to conduct interviews with the participants. All the necessary archived documents (the national mathematics curriculum, WAEC syllabus, two years (2014 and 2016) Chiefs Examiner Reports and samples of May/June WASSCE past questions papers for five years (2013 to 2017) that the researcher had not collected were finally collected during this period. The researcher thanked the participants and expressed his appreciation for their contribution to the success of the lesson observations.

### **5.6.3 Reflections on lesson observations**

Reflecting formally or informally on mathematics lessons is a very important part of a teachers' professional life. Through self-reflection, teachers assess themselves in terms of whether their lessons have been successful. The success of a lesson is ultimately measured by how it has influenced the students' conceptual understanding. Conceptual understanding refers to the successful students' understanding of mathematical ideas and whether they have the ability to transfer their knowledge into new situations and apply it to new contexts. More so, the knowledge acquired at this level is a foundation for higher education. The final measure of a lesson is not how well the teacher prepared for it or presented the lesson. These two measures are but the means to an end. Hence, true assessment focuses on students' learning outcomes or achievement. Positive answers

to such questions as ‘Did the learners understand the lesson content?’ and ‘Have the lesson objectives (which are learner-centred) been achieved?’ can be regarded as evidence of successful lesson preparation and presentation. The participants’ instructional practices in this study are influenced by the Nigerian high-stakes examinations because of their emphasis on the WAEC high-stakes examinations during their lesson presentations and the constant use of past examination question papers.

Teachers’ lesson reflections in the current study showed a preoccupation with instructional success in some of them, in terms of the lesson preparation and presentation of the lesson and the processes involved (see analysis in 5.3 and transcripts in Appendix G). The MKfT is a special kind of knowledge required only for mathematics instructional practices (Ball et al., 2008; Grossman, 1990). The three sub-domains of SMK of Ball et al. (2008) – common content knowledge (CCK), specialized content knowledge (SCK), and knowledge at the mathematical horizon (or horizon content knowledge) – were applied in the teachers’ lesson presentations (see section 5.6 and Table 5.5). The third component of teachers’ SMK, knowledge at the mathematical horizon, described as a provisional category recognizing connections among topics throughout the curriculum was absent in some teachers’ lessons (Teacher C, E, I and J), although three lessons are not enough to determine the teachers’ application of MKfT. However, mathematics curricula knowledge, knowledge of instructional strategies and knowledge of students’ conceptual understanding are supposed to assist the teachers in their mathematics instructional, preparatory and assessment practices in the senior secondary schools.

The focus in their reflections was mainly their own instructional practices and attention was also given to how participants’ instructional practices are influenced by high-stakes assessments. From the three-lesson visit observed from each senior secondary school, the participants focused their instructional practices on two main aspects. The first aspect is that their instructional and assessment practices reflect beliefs and characteristics that imply that teaching mathematics involves showing and telling, with the teachers simply explaining and illustrating procedures for solving problems in mathematics on the board for students to copy and later do classwork/assignments. The second aspect is that the teachers instructional and assessment practices were focused on preparation for WAEC

and other high-stakes examinations regardless of students' conceptual understanding. The next section analysed the teachers' interviews.

### **5.7 Interviews with teachers on the effect of high-stakes examinations on their instructional practices and strategies**

The researcher conducted semi-structured interviews with the ten Kaduna State senior secondary school mathematics teachers individually after the final lesson observation was completed (see subsection 4.4.3). The data from the ten mathematics teachers interviewed were used for the qualitative analysis. Qualitative interviewing was used to understand the experiences of the participants and the meaning they made of those experiences in relation to their instructional and assessment practices. The aim of the interviews was to learn more about the teachers' instructional and assessment practices, the effects of the mathematics WASSCE high-stakes examinations on these practices, and their views/beliefs on effective teaching and meaningful learning of mathematics as well as opportunities and challenges faced by classroom teachers and WAEC in their CA practices.

The questions selected for the interviews were about the description of a typical senior secondary school mathematics class, instructional and assessment practices; views on the WASSCE high-stakes examinations system and its influences on instructional practices. The ten participants in the ten Kaduna State senior secondary schools were interviewed about their instructional practices, preparatory and assessment practices to find out how these practices are influenced by high-stakes assessments and to verify during lesson observations whether what they said was their actual practice.

The first thing the researcher enquired about in the teachers' interview was whether they used the national mathematics curriculum as their reference document and its content compared to the WAEC syllabus. The participants responded that they were using the senior secondary school mathematics curriculum together with examinations past question papers in their instructional practices. Teacher A responded that:

*A teacher is neither a slave to the curriculum nor to teaching methods. We follow the content of the curriculum and we break the content into scheme of work for use*

*in our daily lessons. Although, I use the curriculum alongside some WAEC and NECO examination past question papers.*

Teacher E said:

*The curriculum is my working document in the school. I normally break it into scheme of work so that I will easily know the topics I will teach in the week and plan my lessons at the weekend.*

This confirmed what the participants were doing during their lessons. Using the curriculum alongside the past examination question papers shows that they are influenced by the high-stakes assessments in their instructional practices (see section 5.6).

It was inquired from the respondents to explain whether there is similarity between the mathematics curriculum and the WAEC syllabus. They agreed that the WAEC syllabus is an off-shoot of the national mathematics curriculum. Some of them responded as follows:

Teacher A:

*The school is operating with the national mathematics curriculum which is in line with the WAEC syllabus. And I sometimes do not cover all topics in the curriculum because of time constraints like frequent holidays, strikes, ethnic/religious conflict.*

Teacher H:

*The national curriculum is the same with the WAEC syllabus. I used them concurrently in preparing my scheme of work each term and in planning my daily lessons.*

The participants were asked whether they have freedom to choose their methods of teaching and the type of instructional strategies they use. From their responses it shows they have freedom to choose any method of teaching they want. For example, these were some of their responses:

Teacher A:

*One can use any method provided that the method focuses on understanding of important and relevant mathematical concepts from the mathematics curriculum.*

Teacher B:

*I use methods that suit the topic I taught to my students. And our principal always emphasized that we use the appropriate method that will make the students understand the mathematics taught to them and ensure that the students perform well in the WASSCE [West African senior school Certificate Examination]. You know, the school and we the teachers have an image to protect. Although, I have observed that the teaching of SSS3 (senior secondary school 3) has become examinations affair.*

Teacher H:

*I choose my method of teaching. The mathematics curriculum and the WAEC syllabus are the road map that guides me in my teaching. I break the mathematics curriculum into scheme of work for each term so that the work will be easy for me. I follow the topic strictly in order to help the students pass their examinations.*

The responses from Teachers A, B and H indicated that the national mathematics curriculum and WAEC syllabus are similar in content. The documents analysis of the national mathematics curriculum and the WAEC mathematics syllabus also give a similar views (see section 1.4.6). Additionally, when teacher B mentioned that they have an image to protect shows how some of the teachers' instructional practices are influenced by WAEC high-stakes examinations.

For the type of instructional strategies teachers use in teaching the students, the participants responded that they use lecture, demonstration, discussion and inductive method, and questioning techniques. Below were some of their responses:

Teacher H:

*I use whole class instruction, questioning techniques, and the lecture and demonstration method. However, most of the time I use lecture method to enable*

*me cover much from the syllabus before WAEC examinations in June 2018. Sometimes there is no time for other methods because they waste my time.*

Responses from the interviews confirmed the types of instructional strategies the participants used during the lesson observations. The lecture method, teacher-centred instruction, textbook-bound and use of past examination question papers are strategies that will enable teachers to cover much from the curriculum as they think there is no time for other methods. The use of other methods will waste time in preparing the students to pass the high-stakes assessments. These are the instructional strategies Popham (2001) called teaching to the tests and Julie (2013a) examination-driven instruction (see section 3.2.1). For example, Teacher E stated that:

*Out of pressure on us from students, principals, parents and others stake holders about this WAEC high-stakes examinations we end up rushing the teaching. For example, some politicians will be telling us to make sure their wards or children pass the WASSCE. We end up rushing the teaching of students toward the WASSCE by using past examination question papers in the class as examples, classwork and assignment. Personally, when setting the end of term examination, I always pick the questions from the past WASSCE question papers.*

Teacher H said:

*I emphasized on WAEC's WASSCE to my student in the class during teaching to protect my image and that of the school. So that when the students perform well in the examinations, the glory also comes to me that I have taught the students very well.*

Teacher E lamented about the pressure placed on them by students, principals, parents and other stakeholders as the main driving force to teach for success in WAEC high-stakes examinations, while Teacher H has a more professional reason of protecting his professional integrity and that of the school. Popham (2001, 2003, 2004) contends that there is no way teachers who are under pressure of preparing students for high-stakes examinations can provide students with curriculum-teaching if they do not have a clear description of the knowledge and skills represented by the examination items. For

teachers to focus instructional practices on the curricular content that an examination represents means they need to plan very well to meet the challenges in the school system. However, teachers are to plan and deliver targeted lessons to achieve mathematics curricular outcomes a high-stakes examination represents.

The mathematics instructional strategies are very important in the classroom because they enhance interaction between the teachers and students around the content of the mathematics curriculum directed toward facilitating students' achievement goals. Therefore, teachers need to handle these instructional strategies in the era of high-stakes assessments because of their washback effect. A strategy that is used for memorization of solution procedures will not lead to mastery of mathematics knowledge and skills. Many procedures are not remembered correctly or not remembered at all, and sometimes the students get confused about the right procedures to follow when trying to recall them during examinations. Evidence of effective instructional practices should be based on the observed quality of instruction the teachers provided to the students in the classrooms. These learning opportunities give the students constructive understanding of mathematics and access to legitimate mathematical knowledge and skills (Popham, 2001, 2003b; Schoenfeld, 2016, 2017a).

The participants were asked about the types of instructional materials they used in their instructional practices. They responded that they used the recommended textbooks, comprehensive mathematics revision for SSCE and questions and answer in mathematics, past examination question papers and other instructional materials like mathematics instruments, cardboard papers, graph board and graph sheets, cards, coins, etc. were also mentioned. Teacher J for example, commented that:

*These revision textbooks helped me very well in the teaching of mathematics as a novice in mathematics. They also helped me in preparing the students toward their final examinations – the WASSCE, SSCE and UTME. I make sure they practice and follow the procedures that will give them the accurate answer as in the past examination marking scheme. I have discovered that the questions in the textbooks are not related to the past examination question papers. I either use revision textbooks containing past examination papers or the past quest papers*

directly. Selecting questions from the recommended textbooks sometimes waste my time that is why I go directly to question papers or revision textbooks.

Teacher J, as a novice teacher, found these resources extremely helpful as he tried to stand on his two feet as a non-professional mathematics teacher. The extent of dependency and fluency in using a combination of resources to prepare students for high-stakes examinations will vary according to a teacher's teaching experience.

Teacher C responded that:

*I sometimes use the textbooks but in using them I discover that some topics are irrelevant to the popular questions previously asked in the WASSCE past question papers. I have to reverse back to the WAEC past question papers to be relevant in the preparing the students for the WASSCE. I also see how relevant the mathematics content is to the questions that may likely appear in the next WASSCE. However, when I want to incorporate mathematics textbooks with the past examination paper I mostly use revision textbooks because they content past examination papers that are sometimes repeated with modification of question wording and/or figures. In my revision I sometimes follow suit by restructuring the questions I solve for the students in the class and the ones I give them to practice.*

Teacher C's responses showed that his interaction with the students was dominated by past examination question papers. As observed in the lesson observation, the responses reflect his classroom instructional practices (see section 5.6.1). The core function of instructional and preparatory practices of the teachers is influenced by past examination questions. They sometimes see the content of the past examination papers as very important in terms of what mathematics is taught and how it is taught, more so than the prescribed textbooks. These instructional materials are useful to the teachers in their instructional practices, but it depends on how skilfully the teachers have been using them in their classrooms. However, materials like revision textbooks and past examination question papers were mainly to prepare the students for the high-stakes assessments.

The participants were asked how they engaged their students in their instructional and assessment practices. They said that the students are engaged by listening attentively,

doing the assigned work, showing enthusiasm for work by taking initiative to answer and pose questions (see section 5.3.1). The participants also responded that they normally advised the students to spend quality time reading their textbook, notes, practising questions in the textbooks and past questions papers, memorized solution procedures from the questions for the examinations and trying to understand the underlying concepts in mathematics. For example, Teacher A said,

*For the students to equip themselves very well for examinations, they need to spend quality time reading their textbook and their notes, practising questions in the textbooks and past examination questions papers, memorized of solution procedures from the questions for the examinations and trying to understand the underlying concepts in mathematics.*

Teacher A's response suggested the use of some of the revision practices reviewed in section 2.5. His advice is contradictory. It is good to advice for the students to study well, but the issue of memorizing solution procedures from the solved past examination question papers negates Popham's (2001, 2003, 2004) and Schoenfeld's (1992, 2016, 2017a, 2017b) principles of teaching for conceptual understanding and sense making in mathematics. Teacher A alluded to 'mass practice' and was likely doing it in ways that Julie et al. (2016) write about. According to Julie et al. (2016), students use mass practice when they repeatedly practice and get used to solution strategies of mathematical problem types that they will likely come across in the high-stakes assessments.

The participants were asked whether they engage in professional collaboration by sharing ideas with other mathematics teachers. This professional collaboration focused on mathematics teachers' professional development practice/opportunity to share ideas with colleagues in the teaching service. They responded that they share ideas with colleagues within and outside the school. Teacher A explained that they collaborated with each other especially during WASSCE marking on issues relating to instructional and assessment practices. For example, he responded:

*In fact, we always discuss intensively during coordinating and marking of May/June WASSCE on issues concerning the mathematics curriculum, WAEC syllabus and*

*how WASSCE questions are designed. We also share ideas on how to effectively teach the students to pass mathematics and confidently face the classroom challenges.*

Teacher D also said they collaborated with each other's especially during WASSCE marking on issues relating to instructional and assessment practices. He said,

*I mark and supervise WAEC and NECO examinations. We always discuss and come up with alternative ways of approaching WAEC or NECO questions during coordinating and marking of May/June WASSCE and July/August SSCE. We also share ideas on the standard of the questions and whether the questions are correctly set by the examiners or not and make suggestions for improvement in mathematics teaching and learning.*

Teacher C said,

*We make consultations when we sometimes have difficulties in some topics in the syllabus or forget how to solve some questions in mathematics.*

. Teacher I said,

*I contact my colleagues in teaching mathematics, if the need arises to discuss matters concerning the teaching of mathematics such as difficulty in teaching some topics in the curriculum and difficulties students have in answering some questions in the standardized examinations.*

The responses from Teachers A, C and I expressed that mathematics teachers engage in professional development collaboration within and outside their schools, and during the marking of high-stakes examinations. Advising each other to always do what is expected of them in their instructional practices and teaching the students for conceptual understanding is emphasized by Popham (2001, 2003b, 2004) and Schoenfeld (1992, 2016, 2017a). They also collaborate on the use of the WAEC high-stakes examination marking schemes as guides in their revision practices. This is because the marking scheme contains many possible correct solution methods and where learners produce further correct solution paths these are added to the memorandum of marking. The

professional collaboration is good, but how often do the teachers meet to discuss and consult each other for effective instructional practices? The researcher would have preferred seeing the teachers conducting instructional collaborations or team teaching, grouping students for instructions and whole group instructions that will allow students to share multiple solution strategies.

Participants were asked to explain how they prepare the students for the WAEC high-stakes examinations and how such instructional and preparatory practices are influenced by the examinations. The strategies they commonly employed in preparing the students for the WASSCE were the use of mathematics textbooks, past examinations question papers during lessons as examples, for assignment and tests and frequent emphasis to the students on the high-stakes examinations in most lessons observed. The examinations motivate them to teach for the students to be successful in the high-stakes examinations.

Teacher C responded,

*My teaching is focused on the WAEC and NECO examinations the students write annually May/June and July/ August of the year, respectively. I use past examination question papers to teach my students so that they can perform excellently in both the internal and external examinations. Hmm... When teachers change their method of teaching toward drilling the students for external examination like WASSCE, they do it not out of conviction but out of excessive demand and pressure from principals, students, parents and other stakeholders in education.*

From Teacher's C response, teachers have become tools for implementation of what high-stakes mathematics examinations demand of students and has resulted in their losing control over teaching mathematics content for robust understanding. The pressure on teachers sometimes is so radical that their professional lives and integrity have become diminished.

Teacher B said:

*It is very important to always remind the students frequently about the forthcoming examinations in May/June 2018 and teach them toward the examinations. This reminder will always make them know that they have a task ahead of them. In addition, I always have problems of time constraints in trying to explain some difficult concepts that students do not understand easily in my lesson. In such cases I do refer them to the recommended textbooks and also advise them to study in groups with their classmates to share ideas.*

Teacher I said:

*The examinations influence my method of teaching. Most of the questions I solved with the students in the classroom are always similar to the ones that are set in the examinations. It is also very important to cover the syllabus before the students start any standardized examination.*

Teacher C said:

*I have to define and explain concepts, give examples and show students can use the shortest and quickest way possible of arriving at the solution to mathematics problems and other possible solutions to mathematics questions. I also allow them to copy examples that will help them do their class work, assignments and practice past examination question papers.*

Teacher H said:

*Examinations influence me on what to teach and how to guides the students on how to attempt the examinations questions. I direct my instructional practices toward examinations and constantly revised past examinations question papers.*

The high-stakes examinations influence the teachers in their instructional practices by compelling teachers to use examination-driven instruction explained by Popham (2001a, 2003). Popham's goal is to guide the teachers to an understanding of the misuses of high-stakes examinations, and to develop the insight to distinguish between tests or examinations that are instructionally useful and those that are not. The effect of high-stakes assessments on mathematics teachers' instructional practices is that teachers

focus their instruction geared towards preparation of students for examination scores instead of teaching for robust understanding and sense making in mathematics.

The participants were also interviewed on how much time they take to prepare the students. As mentioned earlier, (section 1.4.7) Nigeria senior secondary education system operates three terms annually. First term is between September and December; the second term is between January to April; and the third term is from May to August. The SSS3 students write their WASSCE in the third term in May/June annually. According to Teacher J, he teaches the SSS3 students in the first and second terms, and does some revision practice with the students towards the May/June WASSCE. Teacher J explained,

*I normally cover the content of the curriculum by the end April and make thorough revision with the students in preparation for WAEC examinations. The third term is virtually left for students' revision. Except, in cases, where the school calendar is interrupted by unforeseen circumstances like the last ethnic/religious crisis that took place in November to December 2016 in Southern Kaduna where schools were closed for sometimes because of insecurity in the area.*

The common practice observed in the ten-selected schools is that the first and the second terms are used for teaching, while the term from January to May is used for revision with the students in preparation for the WAEC high-stakes examinations. Teachers teaching SSS3 as graduating classes are supposed to plan ahead to be able to cover the content of the curriculum and prepare the students for the high-stakes examinations.

Participants were asked about the strategies they use in assessing their students. They said they used a range of assessment strategies. They use questioning techniques, give the students classwork, the take-home assignment, tests and end-of-term examinations (see section 5.6). These assessment practices used by the teachers are formative assessments. Schoenfeld (1992, 2016, 2017a, 2017b) explains that formative assessment are classroom activities that reveal the current state of students' understanding during the learning process. According to Schoenfeld, the assessment practices reveal the ways in which students are making sense of the mathematics content as they learn, and provide the teacher and the students' opportunities to build upon the

understandings that students have developed. They also address emergent misunderstandings in the students' learning. However, from the lesson observations only few teachers asked their students questions during instruction. Teacher B responded that:

*Teachers' achievement of objective(s) of the lesson is shown by the students' responses to questions in the class and performance in classwork assignments, tests or examinations. At the end of every lesson presented teachers are expected to evaluate their lessons by asking students questions and/or their classwork will give the teachers feedback on the level of students' achievement in the lesson taught.*

As observed from the participants, they always state their behavioural objectives in their lesson plan as recommended in the Bloom's (1956) taxonomy of educational objectives. During their presentation some of them use to ask the students whether they understand their lessons or not. These opportunities were very few during the researcher's lesson observations.

The participants interviewed were asked whether the extramural or extra lessons were necessary in preparation for high-stakes examinations. Extramural or extra lessons are informal lesson organised in Nigeria by schools, groups or individuals to coach students in preparation for high-stakes examinations like the WASSCE, SSCE, NABTEB, UTME, amongst others (see section 1.4.4). Teacher C explained:

*The extra lessons have an impact on the students' performance. An effective and well organised extra lesson can make those who organized it to teach mathematics topics that we the senior secondary school teachers in the school system were unable to cover. It gives the students opportunity to prepare very well for the WAEC or NECO examinations.*

It is important know that teachers are not only influenced by WAEC high-stakes examinations as far as the content covered is concerned. Other high-stakes examinations like NECO examinations also have an impact on mathematics instructional practices. NECO is an indigenous high-stakes examinations body similar to WAEC high-stakes examinations. The two examinations use the same national curriculum as instructional

document and the results obtained from either WAEC or NECO or both can be used by candidates to obtain admission to higher education institutions in Nigeria. The NECO examination was introduced to break the monopoly of WAEC examinations in Nigeria (see section 1.4.6.2).

Teacher B said:

*I see it necessary if parents and the schools see the need of organising such classes for their children or students. The advantage is that the normal school hours may not be enough for some teachers to cover the curriculum. Extra lesson may be organized to compensate time lost from disruption of classes in the schools likely because of unnecessary public holidays and sports activities like inter house or inter schools' competitions, among others.*

Most extra lessons in Nigeria are either organised by the schools or groups of individuals and charge for the services rendered. The individual student or the parents of the students bear the cost of those services for those who can afford the charges. There are no ethical considerations attached to such practices. These lessons are for drilling and coaching students to be to pass the high-stakes examinations. These extra lessons can lead to truancy from school or paying less attention to normal classes, believing that they have alternative lessons that can assist them pass the examinations. Such instructional practices are contrary to the frameworks of Popham's effective instructional practice and Schoenfeld's framework of teaching for robust understanding.

However, Popham (2001) explains that when a teacher's instructional practices are either focused on the actual items found on a test or around a set of look-alike items, or the teacher directs instruction toward the body of knowledge or skills that a test represents, such instruction teaches to the knowledge or skills represented by a test. He thinks that such teacher efforts should be rewarded. Julie (2013a) also contends that if students learn mathematics in environments fostering the explicit use of these repeated practices, then they will develop flexible ways of knowing and be able to productively deal with mathematical problems in a variety of situations, including high-stakes examinations. According to Julie (2013a), such learning environments focus on the promotion of the mastery of products of the established knowledge of mathematics. Hence, meaningful

mathematics instructional practices are intimately connected with learning environments which foreground the process aspects of mathematics and examination-driven instruction (see section 2.3). Additionally, teachers should have a belief that students experience learning mathematics in environments that develop their cognition, agency, ownership and identity dimensions and have opportunities for equitable access to content that engages them in meaningful learning (see section 3.2.2).

### **5.8 Interview results on the effect of WAEC high-stakes examinations on mathematics teachers' beliefs about what it means to teach mathematics effectively**

This section focuses on the effect of high-stakes assessment on teachers' beliefs about what it means to teach mathematics effectively. It is concerned with how high-stakes assessment influence mathematics teachers' beliefs in their classroom instructional and assessment practices.

During the preliminary interviews with the participants the researcher had an introductory conversation when he asked them about their general views and beliefs about teaching mathematics in the senior secondary school. They expressed different beliefs about what it takes to teach mathematics effectively in relation to the influence of high-stakes assessments. Teacher A asked his students questions during the lesson, giving them classwork, take-home assignments and tests/examinations, and made sure students' work is marked and corrections are done. The strategies he used in preparing the students for the WASSCE were the use of past questions papers during lessons as examples, for take home assignments and tests. He responded:

*During a lesson I make sure I explain the concepts to the understanding of the students, ask students questions during the lesson, give them classwork, take-home assignments and tests/ examinations, and make sure students' work is marked and corrections are done. I also prepare my students for the WASSCE using past questions papers during lessons as examples, for take home assignments and tests. The way questions are asked in the past examinations gives me a clue on what and how to teach the students. In fact, in this senior secondary school class our instruction focuses on the final examination the*

*students are taking at the academic session [WAEC examination is conducted in May/June and NECO is conducted in July/August].*

This showed that the teacher A used examination-driven instruction and high-stakes examinations influence his beliefs practices. Teacher A's instructional and assessment practices are influenced by high-stakes examinations for using the structure of the past examination papers as a guide to his instructional practices. He also added that their instructional practices are focused on the WAEC/NECO high-stakes examinations.

Teacher C expressed a belief that an effective mathematics teacher has passion for the subject. He elaborated that:

*As mathematics teachers in the senior secondary school one need to be committed and develop instructional strategies for effective teaching and meaningful learning of mathematics. The teaching of mathematics should also be done in such a way that will enable students' success in their examinations.*

Teacher D expressed a belief that an effective mathematics teacher should be patient during his/her instructional practices. He was teaching in a girl's secondary school. He responded that:

*These students have concluded that mathematics is a very difficult subject. Had it been mathematics is not a core subject in the school curriculum and in the WAEC and NECO examinations the majority will not take it. One needs to encourage them to be committed in the learning of mathematics.*

Teacher D seemed discouraged because of the kind of attitudes his students are showing toward mathematics. This is not surprising with the current level of students' performance in mathematics in the WAEC's WASSCE and other high-stakes examinations. That is the reason that led Ukeje (1986) to comment that mathematics is one of the most poorly taught, widely hated and abysmally understood subject by students in Nigerian senior secondary schools.

From our interaction, Teacher H expressed a belief that the teacher is a facilitator while the students are passive listeners, who copy and practise what they have seen and heard. Teacher H responded,

*Students learn mathematics when they sit, listening carefully, and watching the teacher explaining mathematics concepts with examples, and the students copy and practise what they have seen and heard from the teacher. They possibly do classwork and/or assignments.*

The responses of Teachers A, C and D are evidence that their beliefs about effective instructional practices were influenced by the WAEC high-stakes examinations. Teacher H also indicated that the students were passive listeners from the way he explained his instructional practice procedures.

Participants were asked to describe a typical Kaduna senior secondary school classroom. Almost all of them said that teacher is teaching the students and the students are engaged in the lessons by listening attentively, doing the assigned work and asking questions for clarification. According to Teacher G, a typical classroom setting is:

*Students sitting in rows and columns of desks and benches facing the teacher writing on the blackboard. The teacher writes the topic on board and asks the students questions on the previous lesson taught. After that, he introduced the topic of the day and explains the concepts, gives examples, gives classwork and moves around the classroom marking and correcting the student and concludes by giving the students' work assignments.*

From the analysis the mathematics teachers believes that the students passively receive knowledge from the teacher. Their instructional and assessment practices as observed, and the interviews reflect characteristics that imply that teaching mathematics involves showing and telling, with the teachers simply explaining and illustrating on the board for students to copy and later do classwork/assignments. These beliefs and instructional practices undermine the principles of TRU proposed by Schoenfeld (1992, 2016, 2017a, 2017b), where instructional practices are student-centred. The instructional and assessment practices of the participants reflect the traditional beliefs of effective teaching

of mathematics as proposed by Raymond (1997) (see Table 2.2). Raymond (1997) outlines the difference between the traditional and non-traditional beliefs about effective teaching of mathematics. The traditional teacher believes that the role of the teacher is to spoon-feed the students with the mathematics knowledge and skills that students can apply during the high-stakes examinations. The non-traditional teacher believes that the role of the teacher is to effectively teach mathematics by engaging the students in the teaching/learning process and create an environment that make provision for the learner's ideas as well as structured instructional practices that encourage students to grapple with mathematical ideas and problems.

Van der Sandt (2007) links teacher beliefs to the type of activities performed in a mathematics classroom and the view that teaching is driven by making sure learners master procedures and algorithms that will assist the students in the examinations. However, Pajares (1992) explained that there is a strong relationship between the pedagogical beliefs of teachers, their instructional planning, instructional decisions and classroom instructional practices. Teachers' beliefs about effective teaching of mathematics in this study were influenced by the predominant use of traditional teacher-centred method, rushing to cover the curriculum by using past examination question papers or examination-type of questions from revision textbooks. In conclusion, all of the above point to the strong structuring effect of high-stakes assessments on mathematics teachers' beliefs about effective instructional practices.

### **5.9 Challenges and opportunities faced by senior secondary school mathematics teachers in their continuous assessment practices related to WAEC high-stakes examinations**

Continuous assessment (CA) in Nigeria is a comprehensive and systematic process of using relevant assessment techniques and tools to determine the overall progress of students over a period of time in the school system (Amandi, 2013; Birhanu, 2013). CA is part of feedback given to students, teachers, parents and other stakeholders in education about students' progress in the teaching/learning process or lack of it. The aim of the interviews on the aspect of CA was to determine opportunities and challenges faced by classroom teachers and WAEC high-stakes examinations in their CA practices. It was also to ascertain the level of trust that can be conferred on the components of the

WASSCE final grades awarded to the students with the inclusion of schools CA. Reasons were mainly based on mistrust and lack of objectivity or fairness in arriving at the final scores.

The researcher tried to understand the problems the participants faced regarding their assessment practices. They mentioned pressure from various quarters with respect to the high-stakes examinations and problems arising from CA practices. Some of the participants gave their responses as follows:

Teacher A,

*In this our work we are facing challenges such as pressure from students, principals, parents and other stakeholders regarding students' success in the high-stakes assessments. This pressure does not warrant to follow the normal classroom practices.*

Teacher B said,

*The examinations organized in Nigeria are too demanding and stressful to teachers teaching the [senior secondary school 3] SS3 and when combined with other school responsibilities like compiling of continuous assessments [CA], supervising and invigilating both internal and external examinations.*

Teacher A also lamented that one of the problems he faced in the mathematics classroom was the students' inadequate ability to communication in the language of instruction. He said,

*If you define and explain concepts with examples, when you pause and ask students questions to formatively assess whether they understand you or not, nobody respond. You discover during classwork that some of them understood you, but how to express themselves in the English language is the problem.*

English as second language and as a language of instruction and assessment could be responsible to the students' lack of response to teachers' questions and can also discourage some teachers from asking the students questions during instruction.

Teachers' opinions on the 20% CA score use by WAEC high-stakes examination as part of the total score in the WASSCE were sought. Some of the participants (Teacher A, C, D, F, G and I) suggested that the system should be abolished because some schools always fake those scores while others (Teacher B, E, H and J) said the system should be maintained because it is in the Nigerian national policy on education to supplement candidates' scores and grades. It was also confirmed that the school-based assessment (SBA) is 15% for classwork and assignments, 15% for tests and 70% for end-of-term or year examination, that is, 15:15:70. This system is used cumulatively from SSS1 to SSS3 and then the 20% score to be added to WASSCE is calculated. Teacher A responded:

*I compile the 20% CA for our school to be given to WAEC, supervise and mark the WASSCE high-stakes examinations. I wish to suggest that WAEC should abolish that CA system. I will sincerely compile our students CA scores while other schools will fake high CA scores and take to WAEC. Some of these CA scores schools send to WAEC do not give a true reflection of their students' performance. I am contesting again it seriously.*

Teacher D said the SBA used by WAEC as part of the total score in the WASSCE should not be used because some of them are fake scores. According to him,

*WAEC should only determine the students' performance from their WASSCE scores only and therefore, should not use the CA because some centres sent fake scores that do not give a true performance of the students. At the examination period WAEC should strictly supervise all the centres because there are very good in examination malpractices and they are so-called magic centres.*

Teacher E responded that:

*The CA policy is enshrined in the Nigerian nation policy of education.*

He further emphasized that,

*The examination system in Nigeria is alright, well organised but the examination ethics need to be reviewed.*

Teacher G responded that:

*I am not in support of that CA that is send to WAEC because it does not reflect the true performance of the students in some senior secondary schools, especially the private schools. The private schools operate to maximize profit; therefore, they inflate CA scores so that all their candidates will past the examinations.*

Teachers A and D believe the SBA used by WAEC high-stakes examinations in the WASSCE should be abolished because of the faking of such assessment in some senior secondary schools. Teachers E and G expressed the opinion that the CA is part of the national policy on education in Nigeria. The national policy on education (FRN, 2004) states that the SSS3 students' performance in WAEC and NECO will be determined by SBA scores and the examination scores.

A system of combining 20% school-based CA scores with 80% WASSCE scores in WAEC high-stakes examinations was introduced in Nigerian senior secondary schools (SSS). At the end of the three-year programme of the SSS an average percentage score for each student is computed and submitted to WAEC to form part of the final grade of the student. The researcher tried to ascertain the level of trust that can be conferred on the components of the WASSCE final grades awarded to the students with the inclusion of schools' CA and mistrust and lack of objectivity and/or fairness in arriving at the final scores. He got a personal communication from Mathias (2018) on the formula used by WAEC in moderating the CA from the senior secondary schools. Due to the incomparability and incompatibility of the CA scores from schools across the country, WAEC high-stakes examinations moderate the CA scores using the WASSCE scores before combining them with the final WASSCE sores for grading candidates. The moderation method is a linear transformation procedure (using software) where the students' CA scores (i.e. the three-year score averages) in mathematics are adjusted so that their distribution has the same mean and standard deviation as the distribution of the scores on the WASSCE for that school. The scaling formula for each candidate is:

$$CASS (Mod) = TASS (mean) + \frac{TASS (SD)}{CASS (SD)} X [CASS (raw) - CASS (mean)]$$

where,

CASS = Continuous Assessment Score (school-base assessment SBA);

TASS = Total Assessment Score (SBA and WASSCE score); and

SD =Standard Deviation.

The formula is the moderated CASS equals the TASS mean in the school plus SD of the TASS divided by CASS times the difference between the raw CASS and the CASS mean. According to Mathias (2018), the marks from the internal assessment (CASS) for each assessment are adjusted to give the mean and standard deviation as the distribution of marks for the moderating instrument (TASS) of the candidate in the school. Therefore, the school CA used by WAEC high-stakes mathematics examinations is moderated and added to the final score a candidate obtained in the WASSCE. This showed that trust can be conferred on the components of the WASSCE final grades awarded to the students with the inclusion of schools' CA and there is objectivity or fairness in arriving at the final grades, which is educationally meaningful.

By implication, the school's overall performance in the WASSCE is used to moderate CASS. Hence the standard deviation units of the CASS are linked to the mean of the TASS. That means, even if schools inflate their scores, they will be recalculated based on the school performance mean in the WASSCE. Additionally, even if a school inflates CA marks, they will be automatically adjusted downward by the school mean. Using the WASSCE scores to moderate the CA scores of candidates brings down the school-based CA scores to follow the performance pattern of the candidates in the WASSCE. Therefore, the candidates who perform poorly in the WASSCE will be disadvantaged in the moderation of the CA scores. It is likely that the senior secondary school teachers and their school administrators are not aware of these assessment practices by WAEC high-stakes examinations.

Mathematics teachers' professional development (PD) in this study was regarded as one of the opportunities that teachers have in the teaching profession. Participants explained that there is provision for teachers to further their education at any university of their choice through in-service training. Workshops, seminars and conferences are always

organised, but sometimes principals are not ready to sponsor their teachers to attend. For example, Teacher I responded that:

*My principal has been encouraging me to go back for my master's degree that he will recommend me to the Kaduna State Ministry of Science, Technology and Education for the in-service.*

Teacher G said,

*Teachers can further their education through the so called in-service because the teachers go for studies are not sponsored by the government. School principals and government do not encourage teachers through financial assistance to attend workshops, seminars and conferences.*

Mathematics teachers' professional development is paramount for teacher to improve and update their knowledge in MKfT (Ejima & Okutachi, 2012; Gierdien, 2008; Ndlovu, 2014). Mandatory Continuing Professional Development (MCPD) is meant to ensure that teachers are well-informed of changes in the theory and practice of mathematics as well as shape their beliefs on effective teaching and meaningful learning of mathematics.

## **5.10 Conclusion**

This chapter presented narratives of the lived experiences of selected senior secondary school mathematics teachers to allow the reader to have an insight into the possible effects of WAEC high-stakes examinations on their instructional and assessment practices. The demographics of the selected schools and participants were analysed. The lesson observations were analysed based on the way the individual participant's portrayed their classroom instructional and assessment practices. The interviews were analysed thematically on how teachers' instructional practices and teachers' beliefs about effective teaching of mathematics are influence by WAEC high-stakes examinations. The researcher also analysed the opportunities and challenges faced by mathematics teachers and WAEC high-stakes examinations in their CA practices. The participants' classroom instructional practices were dominated by whole class instruction. The findings from the lesson observations revealed that the common classroom instructional, preparatory and assessment practices by the participants were: introducing the lesson

using previous knowledge or solving previous classwork or assignment; then introducing the new topic by definitions and explanation of mathematical concept with working examples; giving students classwork and assignments from WAEC and/or NECO past examinations question papers; and sometimes marking the classwork or the assignments.

Most teachers used the chalkboard (e.g., Teacher A, C, D, E, H, I and J) because of the lack of better resources and technology, the traditional lecture method was used to frantically prepare students for examinations, lessons presented predominantly covered mathematics content that included past examination question papers or examination type of questions from revision textbooks. Teachers could not use learner-centred approaches (which showed weak PCK) mainly because of overcrowding in classes as well as the rush to cover the syllabus, amongst other reasons. Most of these practices were therefore what Popham (2001) described as teaching to the test and an antithesis of Schoenfeld's (2017) framework of teaching for robust understanding. Although teachers showed sound knowledge of subject matter (SMK), there was little regard for PCK that takes into account MKfT or KCS. Teachers knew the curriculum to be assessed very well, but their perception of teaching as showing and telling robbed students of meaningful mathematics learning. Most of the mathematics taught was basically at Bloom's level of knowledge recall and routine procedures, but there was very little application to real life and this in turn led to meaningless drill as the dominant instructional and preparatory practice, amongst others. The obsession for students' success in the high-stakes assessments mounted pressure on teachers from students, parents, principals and other stakeholders with high expectations for student success.

Not surprisingly, the above findings revealed that their beliefs and practices were influenced by the WAEC high-stakes examinations and the main challenges were the CA practices within the schools and the CA scores use by WAEC high-stakes examinations as part of the scores in the WASSCE.

One of the opportunities that teachers have in the teaching profession is professional development (PD). Participants expressed the view that there is provision for teachers to further their education at any university of their choice through in-service training, and

attend workshops, seminars and conferences. The next chapter focuses on chapter summaries, discussion of findings, conclusions, contribution to theory and practice, recommendations and suggestions for further study.

## CHAPTER 6

### DISCUSSION, CONCLUSION AND RECOMMENDATIONS

#### 6.1 Introduction

This chapter provides a summary of the chapters and the main findings, and also draws conclusions in the light of the research questions. It also discusses the contribution of the thesis to theory and practice, its implications for the mathematics curriculum and assessment policy, practice, teacher education and development. Finally, it discusses the limitations of this research and makes some recommendations.

#### 6.2 Summary of chapters

Chapter 1 gave an overview of the orientation, motivation and detailed background of the study context. The problem statement was outlined, and the purpose of the study and research questions were highlighted. A brief overview of the methodology and the delimitation of the study were given. Ethical issues and the significance of the study were outlined and the chapter concluded with definitions of key terms and a chapter-by-chapter outline of the thesis.

Chapter 2 reviewed some of the literature related to this study. Literature on how high-stakes assessments influence mathematics teachers' instructional, preparatory and assessment practices and mathematics teachers' beliefs about what it means to teach mathematics effectively was reviewed. The influence of high-stakes assessments on teachers' adoption of examination-driven instruction for WAEC high-stakes examinations and the washback effect were highlighted. Related concepts on mathematics teacher effectiveness such as teachers' knowledge, self-efficacy as well as teachers' opportunities (e.g. PD) and the challenges faced by senior secondary school mathematics teachers and WAEC high-stakes on their continuous assessment (CA) practices were also reviewed. The mathematics teachers' knowledge, goals, efficacy, beliefs, and human and material resources were seen as latent educational variables of senior secondary school mathematics instructional and assessment practices. The senior secondary

school mathematics curriculum, the WAEC syllabus and other learning materials such as textbooks were the material resources with varying levels of availability.

Chapter 3 focused on the theoretical and conceptual frameworks of the study. The study was underpinned primarily by Popham's (2001, 2003, 2004) instructional and assessment practices, Schoenfeld's (2016, 2008, 2017) TRU framework and Bloom's taxonomy (Bloom et al., 1956; Krathwohl, 2002; Leshem & Trafford, 2007). These frameworks served as interpretive lenses to process the data on how instructional, preparatory and assessment practices in Kaduna State senior secondary schools are influenced by high-stakes assessments. The frameworks also reflect on the collaboration between school system, mathematics' instructional practices and assessment practices, and WAEC high-stakes assessments meeting up the demand of Nigerian the senior secondary schools. This chapter also diagrammatically presented the conceptual framework to give a general overview of the intended study (Leshem & Trafford, 2007).

Chapter 4 defined, explained and justified the research design and the of data collection and data analysis procedures. The qualitative ethnographic case study was adopted as a design through which the researcher gathers data and analyses procedures to answer the main research question: What are teachers' instructional practices in preparation for the high-stakes mathematics assessments in Nigerian senior secondary schools? The chapter indicated that the research methodology helps the researcher in a sequence of processes to be followed in a research study. The purposive sampling of ten senior secondary school three (SSS3) mathematics teachers from ten schools to participate in the study was explained and justified. The qualitative study was done within the interpretive paradigm to focus on an understanding of internal reality, subjective experiences through observations, and interviews as primary data sources. The instruments used for the data collection were validated to determine their trustworthiness. Content analysis was used to make sense of the data collected by transforming data into answers to the research questions. Included in this chapter is a discussion on how ethical standards were adhered to in order to ensure scientific integrity.

Chapter 5 presented, analysed and interpreted the data generated from this study. The chapter described the selected senior secondary school mathematics teachers engaged

in their instructional practices to allow the reader to have an insight into the possible effects of WAEC high-stakes examinations on their instructional and assessment practices. While investigating how instructional and assessment practices are influenced by WAEC high-stakes examinations, the analysis of data was done using the theoretical frameworks to evaluate teachers' instructional, preparatory and assessment practices and the beliefs underpinning them. The findings showed that most teachers used the chalkboard due to lack of better resources. Lessons presented were predominantly the traditional teacher-centred method, rushing to cover mathematics content in a way that included past examination question papers or examination-type questions from revision textbooks. Most of these practices were therefore in line with Popham's (2001, 2003, 2004) framework of teaching to the test and negated Schoenfeld's (2016, 2017a, 2017b) framework of teaching for robust understandings. Although teachers showed sound SMK, there was little regard for PCK that takes MKfT into account. Teachers knew the curriculum to be assessed very well, but their perception of teaching as showing and telling deprived students of meaningful mathematics learning. Most of the mathematics taught was basically at the Bloom's level of recall and routine procedures, but very few applications to real life beyond the classroom and high-stakes examinations. These practices were done mainly to prepare students for success in the high-stakes assessments as a response to pressure from students, parents, principals and other stakeholders with high expectations for student success

### **6.3 Summary of findings**

The common classroom instructional, preparatory and assessment practices by the teachers were: introducing the lesson using previous knowledge or solving previous classwork or assignment; then introducing the new topic by definitions and explanation of mathematical concepts with working examples; giving students classwork and assignments (Waxman, 1995) from past WAEC high-stakes examinations question papers; and sometimes marking the classwork or the assignments. The teachers' interviews revealed that the mathematics teachers' beliefs on effective mathematics instructional practices were influenced by WAEC high-stakes examinations. The main challenges faced by the selected Kaduna State senior secondary school teachers were

the CA practices within the schools and at WAEC high-stakes examinations, and the problem of fair practices on such CA scores used by WAEC high-stakes examinations as part of the scores in the WASSCE. It was confirmed that WAEC used a moderation formula to moderate the school-based continuous assessment results. The opportunities teachers have in the teaching profession are their involvement in the assessment of their students and professional development (PD) (Ejima & Okutachi, 2012). The study also revealed that there is provision for teachers' CPD for update of MKfT in mathematics. However, teachers are faced with the problems of self-funding in attending this CDP.

#### **6.4 Discussion**

The study was carried out in ten Kaduna State senior secondary schools, which were in a natural setting and took conventional research procedures. It is important to note that the nature setting refers to the reality of the mathematics teachers' classroom instructional practices, for example, the minimum resources they use to teach the students, the pressure of the high-stakes mathematics examinations as the academic year progresses. This study involved only government senior secondary schools across rural, semi-urban and urban areas, and boys- or girls-only schools and mixed schools, as well as boarding and day systems. These are categories of schools participating in the WAEC high-stakes examinations. The researcher was able to observe the schools, conduct interviews with participants, and make sense of how they interpreted their beliefs and actions about the effects of WAEC high-stakes examinations on their mathematics instructional and assessment practices. Interaction with the participants was all about the senior secondary school operation system and the mathematics teachers' instructional, preparatory and assessment practices toward preparing for the WAEC high-stakes examinations.

The findings from this qualitative ethnographic case study data generated from the field notes taken during lesson observations, transcripts from teachers' interviews and videotape/photographs from the classrooms to gain an understanding of the interactions between teachers and students in the senior secondary school mathematics classroom culture. To be more specific, the essence of the lesson observations, interviews and collection of documents was to find out how Kaduna State senior secondary school

mathematics teachers instructional and assessment practices are influenced by the WAEC high-stakes mathematics examinations.

The discussion of findings from this study is based on responses from the participants' lesson observation and interviews to address the main research question:

*What are teachers' instructional practices in preparation for high-stakes mathematics assessments in Nigerian senior secondary schools?*

The participants in this study had adequate qualifications, except one who had Bachelor of Mechanical Engineering and two who had no university education (see Table 5.2). These result is consistent with the view of Odia and Omofonmwan (2007), and Ogundele et al. (2014) that teachers who had undergone teacher's training are more confident and successful in instructional practices and classroom management than those who did not. Ogundele et al. (2014) argue that ineffective teachers' instructional and preparatory practices for high-stakes mathematics examinations largely emanate from poor PCK and result in poor performance among Nigerian senior secondary school students. Odia and Omofonmwan (2007) accuse teacher training institutions in Nigeria for producing teachers who are inadequate in terms of MKfT. Although teachers in this study showed sound knowledge of subject matter SMK, there was little regard for PCK that takes into account MKfT. They knew the curriculum to be assessed very well but their perception of teaching amounted to showing and telling, and covering the mathematics content in ways that included past examination question papers or examination-type questions from revision textbooks. These practices deprived students of meaningful mathematics learning.

The ten senior secondary schools 3 (SS3) whose students were going to write the May/June 2018 WASSCE had a total student population of 1,582, an average class size of 49, a teacher-student ratio of 1:32 and an average workload of 19 lessons per week for the ten teachers (see Table 5.3). The average class size of 49 students was far above the recommended class size of between 25 and 40 students (FRN, 2004). Adeyemi's (2005) findings revealed that schools having an average class-size of 35 students and below obtained better results in the WASSCE examinations than schools having more

than 35 students per class. Large class sizes prevent teachers from reaching all students and providing adequate opportunities to learn in the classroom. School 5, for example, had a class with 65 students and was excessively overcrowded (see Table 5.3) and the situation did not allow effective teacher-student interactions. Teacher H just gave mass lectures because he had no time to waste. He was hurrying to cover the syllabus before the WAEC high-stakes examination in May/June 2018. According to him, using any other method will waste his time (see section 5.7).

The workload of 30 lessons for Teacher A and Teacher C combined with class sizes of 64 students for Teacher A and 56 students for Teacher C show that some of the teachers were overloaded with instructional and assessment duties. The workload of teachers needs to be reasonable to enable them function well in the school system. Number of lessons taught should be considered concurrently with class sizes for an accurate reflection of workload and larger class sizes normally go with fewer lessons. It is likely because of lack of enough teachers in Kaduna State senior secondary schools and this may affect their effectiveness in their instructional and assessment practices for high-stakes assessments. There were adequate classrooms and blackboards but desks, chairs, exercise books, textbooks, equipped libraries and instructional materials were inadequate. None of the ten senior secondary schools had a mathematics laboratory (see section 5.3). The number of mathematics teachers and other supporting staff were grossly inadequate. Although this is not part of this study, it is important to have background information about the instructional setting of the study area as an ethnographic case study. Inadequacy of human resources and instructional facilities in the school system can also adversely affect teachers' instructional, preparatory practices for the WAEC high-stakes examinations.

The participants were able to exhibit a level of maturity (see Table 5.2), but they had their individual limitations in their instructional and assessment practices. Experience sometimes helps teachers in their instructional practices and decision making in the classroom and the school programmes. These participants in their examination-driven instruction were able to show connections of the content of mathematics within the classroom and between the mathematics content of WAEC high-stakes examinations.

There could be effective management of the classroom and the school challenges. Despite the demand of high-stakes examinations some teachers (Teachers A and D) demonstrated some student-centred approaches (see section 5.6.1) and focused on conceptual understanding but they still focused on WAEC high-stakes examinations.

The discussion of findings on mathematics teachers' instructional practices is also based on responses from the participants' lesson observations and interviews, and the three research sub-questions for this study:

*What are the effects of WAEC high-stakes examinations on mathematics instructional practices and strategies in selected Kaduna State senior secondary school classrooms?*

*What is the effect of high-stakes examinations on the Kaduna State mathematics teachers' beliefs about what it means to teach mathematics effectively?*

*What are the opportunities and challenges faced by senior secondary school's mathematics teachers and WAEC in high-stakes continuous assessment practices?*

The researcher observed the participants' lessons and found that their instructional practices were dominated by whole class approaches. Such instructional practices were confirmed in the teacher interviews. The main reason teachers gave was that the lecture method is the quickest way to cover the mathematics curriculum and prepare students for the high-stakes assessments. There was very little teacher-student and student-student interaction in the few lessons observed (see Teacher A, D and H). Students rarely selected their own learning activities, and they were generally very passive in the classroom, often just watching or listening to the teacher, even though they were found to be apparently on task. The focus was to hurry through the material by coaching and drilling students to know how to write and pass the mathematics WASSCE.

Similarly, Joseph et al. (2011) assert that some teachers often say that there is no curriculum any more, that teachers just get the students ready to take the high-stakes assessments. Joseph et al. (2011) further explained that the traditional methods employed in the mathematics classroom have leaned heavily towards teacher-centred

instruction in which the teacher teaches and the students listen passively. These types of instructional strategies have been discouraged by Popham and Schoenfeld. They advocated for instructional practices that should be student-centred activities, where students are engaged in critical thinking and developing multiple problem solution strategies in mathematics. This would also bring about students' conceptual understandings and access to legitimate mathematical knowledge (Julie (2013a, 2013b). The students should be working collectively or in groups during mathematics instruction and not become passive listeners. However, Afemikhe and Omo-Egbekuse (2010) argue that good mathematics instructional and assessment practices are expected to shun unethical assessment practices, produce students who are enthusiastic about learning and who eventually succeed in high-stakes examinations.

The participants were also observed focusing on either starting by asking questions on the previous lesson or solving problems previously given as class work or take-home assignments. The next step was the introduction of a new topic, definitions and explanations of mathematical concepts, working on examples, followed by giving students classwork and assignments from WAEC and/or NECO past examination question papers. Teachers could not use learner-centred approaches, which was a sign of weak PCK and therefore students did not experience meaningful learning (Popham, 2001; Shepard, 2000; Wayman, 2005). There were not many variations to the participants' lesson presentation, similar to Waxman's (1995) observations. The lack of variation could be attributed to perceived time constraints, the rush to cover the content of the curriculum and prepare the students to pass the WAEC high-stakes examinations. These instructional practices could be rooted in the teachers' beliefs or the pressure to prepare the students to pass the WAEC high-stakes examinations at all cost.

Teese (2000) observes that pressure for students' success in secondary school mathematics progressively intensifies demands on the cultural resources of the students and teacher proficiency in instructional practices.

Almost all the participants displayed similar instructional patterns, which were lecture-based, teacher-centred, chalkboard based, text-book bound and excessively use of past high-stakes assessment questions papers so that they can cover most of the

examined/assessed curriculum (see teacher H, section 5.4). This trend has also been noted by Julie (2013a, 2013b) in the South African context. This finding also supports Ogunkunle's (2007) observation that the teaching of mathematics in Nigeria consists of chalk and talk at the senior secondary school level. Mitchell (2006) thinks that the teacher-centred, lecture-based and textbooks-based approaches that emphasize the solving of problems to give the correct answers and cover the syllabus are typical of examination-driven teaching. Massed coaching of students (Julie et al., 2016) to pass high-stakes assessments is also a widely observed feature in South Africa. A reason given is that such instructional practices help the teachers to cover a lot of content in a short space of time to prepare for the high-stakes assessments (Gengle, Abel & Mohammed, 2017; Oloyede, 2007; Tara, 2005). This shows how instructional practices are conditioned by the high-stakes assessments.

The data from the lesson observations and interviews of the ten senior secondary school teachers revealed that the interaction between teachers and their students in their instructional and assessment practices were dominated by *New General Mathematics 3*, different types of revision textbooks and past question papers on high-stakes examinations. On the part of the mathematics teachers, it was found that the effect of past questions permeates their core functions of instruction and assessment. In the domain of instruction, the teachers see the past questions as the standard and key to students' success in terms of the content taught and the method of instruction, especially when they engage in revision practices (Ericsson *et al.*, 1993; Julie, 2013a; Julie *et al.*, 2016).

In the mathematics curriculum textbooks also provide a framework for what is taught, how it might be taught and the sequence to be followed in the teachers' instructional practices (Shuhua & Gerald Kulm, 2004). They are the main reference documents teachers are supposed to use during their instructional practices, but they almost to have been replaced by past examination question papers. Teachers in this study adopted revision and examination-driven instruction that focus on the use of past examination material to prepare the students for future examinations. There is the likelihood that learner-centred teaching and the use of prescribed textbooks can be frustrating,

considering the time left for them to prepare the students for the WAEC high-stakes examinations.

In this study the participants' examination-driven instructional and preparatory practices therefore focused more on item teaching than curriculum teaching. This is because lessons were presented predominantly to cover mathematics content that included past examination question papers or examination-type questions from revision textbooks. Popham (2001, 2003b, 2004) described two types of teacher's instructional practices as teaching that is focused directly on test items (item teaching) and teaching that is directed at the curricular content (knowledge or skills) represented by test items (curriculum teaching) (see section 3.2.1). The participants focused more on the high-stakes examination questions than the curriculum standard in order to meet the demands of WAEC high-stakes examinations. However, some participants (e.g. Teachers A, D and E) were trying to develop pedagogical strategies that speak to day-to-day realities, struggles, concerns and aspirations of students, similar to Ball and Bass's (2000) idea of the core activities of mathematics instructional practices.

These core activities entail teachers trying to figure out what students understand, analysing methods and solutions different from one's own and comparing them, unpacking familiar mathematical ideas and principles, and choosing representations to effectively convey mathematical ideas. But the pressure from students, principals, parents and other stakeholders regarding students' success in the high-stakes assessment does not warrant such practices (Julie et al., 2016; Sani, 2015). Teaching for robust understanding as advocated by Schoenfeld (2016, 2017a, 2017b) can help students succeed in high-stakes assessments as well as gain meaningful perceptions about learning mathematics. Other participants were observed spending very little time interacting with students or encouraging them to succeed in the high-stakes examinations. This was a sign of deficient PCK, particularly the knowledge of content and students (KCS) as well as knowledge of content and teaching (KCT).

Sometimes the consequences attached to students' success or failure in high-stakes examinations determine how teachers are influenced by such consequences. When the pressure is low the instructional and preparatory practices are done in a conventional

way; where the pressure is high teachers tend to be in control of every activity in the mathematics classroom's instructional practices and students become passive listeners. The instructional practices become teacher-centred instead of student-centred, hence students' learning become memorization of solution procedures to be mindlessly recalled during the examinations. The use of high-stakes assessment accountability as an instrument for effective instructional practices is very possible, but the knowledge acquired through mindlessly memorization of solution procedures may become elusive based on the instructional strategies used.

From the developed countries point of view, these examination-driven instructional practices are similar to the comparative study of the effect of high-stakes assessments on instructional practices in USA and Britain, where Firestone *et al.* (2000) found that teachers relied heavily on past questions in Britain. The culture of past questions is premised on the expectation that similar content will be in the examination each year with only minimal variations. Past examination questions thus become the boundary object that clarifies, to both teacher and students, the extent of coverage required by the curriculum. They also set the standard and point to the Bloom's cognitive levels of performance required in the examination (Firestone *et al.*, 2000; Harlen & Crick, 2003). In the context of high-stakes assessments as pertains in the USA, the findings of Firestone *et al.* (2000) suggest that the examinations drive the curriculum and lead to changes in the curriculum at the local level. Similarly, Wright (2002) found that a district had to review its curriculum to include all the content of the high-stakes examinations, and teachers were told by district supervisors not to teach things that were not required in the examination, since there was no more time left to teach the students. In this study the instructional and assessment practices are influenced via the high-stakes examinations by the use of past question papers, the review of curriculum content and the orders given by the district authority for teachers to hurry and cover the syllabus.

From the researcher's lesson observations and interviews, some participants did not present their lesson plans but filled the lesson preparation forms (see Appendix D) during their teaching periods. They said the lesson plans are an unnecessary administrative burden. Some of the participants further emphasized that with the limited time they have

to prepare the students for WAEC high-stakes examinations, they do not have enough time to follow the content of the lesson plan during instruction. Then there is no need for any lesson plan. For those who presented their lesson plans and filled in the lesson preparation forms, what that was prepared was not exactly what that was finally presented during instruction. However, the content and the lesson presentation were well structured. Nenty *et al.* (2007) emphasize the need for encouraging preparatory and classroom assessment practices as ways of enhancing and measuring the educational system.

Student engagement in the lessons was a traditional phenomenon of listening attentively to the explanation of the teacher, taking down copious notes in their exercise books and doing the assigned work. To some extent the teachers remained as instructors and explainers. This scenario observed in Kaduna State senior secondary school teachers is a reminder of Ernest's (1989) three models of teaching, where the teachers play the role of instructor, explainer and facilitator. The first two models were predominant in the lessons observed, while the third model was conspicuous by its absence. Teachers taught in a way that was dissimilar to the notion of good practice and teaching for conceptual understanding as outlined by Schoenfeld (1992, 2016, 2017a, 2017b). They failed to provide support for students as they engage in mathematical sense making. It is sometimes not possible to actually use the modern method of instruction by engaging the students in variety of activities, because of the preparation for time-restricted examinations like the WAEC high-stakes examinations.

Furthermore, mathematics teachers believed that teachers should plan their instruction well, show interest and enthusiasm in their work, develop effective teaching and meaningful learning, and be flexible in dealing with the students in the class (see Teachers C and D in section 5.5). This belief did not correspond with the teachers' instructional practices during the lesson observations where memorisation of solution procedures dominated, hence the espoused philosophies did not translate into practice. Their beliefs were influenced by high-stakes assessments, because they had to prepare the students for the WAEC high-stakes examinations. Teese (2000), in his study of secondary mathematics teaching, notes that students are taught mathematics heavily through rote learning of manipulative techniques to pass high-stakes examinations

without any emphasis on conceptual understanding. He further emphasized that such instructional practices deviate from the original philosophy of examinations. This is similar to Madaus's (1988, 2014) belief that high-stakes assessments influenced the content of mathematics taught and approaches to the teaching. In other words, they put teachers in a perpetual state of panic.

The observed teachers held beliefs that the strategies that enhance prospects for students' success in the WAEC high-stakes examinations are paramount in their instructional practices. They believed that it is the responsibility of the teacher to show and demonstrate what the student should do. With the high-pressure demand from the high-stakes assessments, it will likely be difficult for such teachers to change their beliefs and to embrace the use of a student-centred approach and develop the idea that all students can learn mathematics if treated equitably. Students-centred approach in mathematics instructional practices allow classroom discourse and give students opportunities to develop their own multiple solution strategies. Therefore, the meaning attached to teachers' instructional practices and strategies in preparation of Kaduna State senior secondary school students for WAEC high-stakes examinations and the types of instructional materials affect what mathematics is taught and learnt.

Time management is considered in this study as an important aspect of instructional practices, where the researcher observed how each participant made judicious use of the lesson time and how they advised their students to spend time studying mathematics. From the ten schools' timetable the lesson periods were slotted for 30 to 35 minutes. Teachers were asked the question "How much time do you encourage your students to spend studying mathematics after normal school activities?" Some of them responded: "An hour or an hour and a half", "...one hour for maths..." etc. (Teachers A, D, E and I). The teachers claimed that they always advised them to spend at least one hour to study after normal school time.

Some teachers believed that it is their responsibility to teach the students effectively. On the one hand, teachers (Teachers A, E and I section 5.4 and 5.5) held the following two positive beliefs about the learning of mathematics: many students are capable of learning mathematics, and students are not passive recipients of knowledge of mathematics –

views supported by many scholars (e.g Fang, 1996; Handal & Herrington, 2003; Madaus's 1988; Pajares, 1992; Tsui, 2003). On the other hand, some teachers (Teachers C, D, F and J) believed that there was no need to waste time on teaching for conceptual understanding, but they emphasized the mastery and memorisation of solution procedures to be used during the high-stakes assessments (see section 5.6).

Mathematics teachers believed that their instructional and assessment practices are guided by the high-stakes assessments because they believe that teaching SSS3 as a graduating class has become an examinations survival affair. The effect is that teachers are likely to feel they are less in charge of how they want to teach and what they wish to cover, because of instructions given by some principals (see section 5.4). However, it is contrary to what WAEC (2014) states, namely that its syllabus is not intended to be used as a speculative teaching syllabus but as a guide to experts in setting and editing the WASSCE questions (Agbeti, 2011; WAEC, 2015) (see section 1.4.6.2). Although some teachers are using the curriculum concurrently with WAEC syllabus in their instructional practices (Teacher H) (see section 5.4), the dominant practice observed in this study was to teach speculatively.

Teachers in this study also believed in teaching styles that spoon-feed students with factual knowledge and procedures (low levels of Bloom's taxonomy) and they expected students to be able to recall or reproduce in the examination. Popoola and Odili (2011) note that there is consistency between teachers' beliefs about how mathematical knowledge is acquired and their instructional practices. Therefore, a perspective on teachers' beliefs provided an alternative interpretive lens for the researcher through understanding teachers' actions and thoughts in their instructional and assessment practices as described in the literature (Pajares, 1992; Van der Sandt, 2007). Teachers' instructional practices were directly observed as examination-driven. According to the participant in this study, preparation for high-takes examinations means teachers should not waste time on irrelevant materials that will not appear in the examination, but should concentrate on content that has the likelihood of being tested.

With respect to challenges and opportunities encountered, participants responded that they collaborate in professional practice (see section 5.4) with other teachers within and

outside the schools to clarify uncertainties in their instructional and assessment practices. They believed that it is not possible to teach mathematics in isolation. Ideas have to be shared and difficult questions have to be tackled together.

Most of the teachers' use of teaching aids (textbooks and high-stakes examinations past question papers) focused almost exclusively on achieving correct answers through depending on the memorisation of facts, rules and definitions and use of the same questions repeatedly to succeed in the WAEC high-stakes examinations (see section 5.3, 5.4 and 5.5). The type of instructional materials selected confirmed the teachers' traditional approaches and beliefs about what mathematics is, and about how it should be taught. Teachers' beliefs greatly influence the mathematics teachers' instructional and assessment practices (Schoenfeld, 1992, 2016, 2017a, 2017b). Schoenfeld (2017a) outlines dimensions of effective mathematics lessons as good mathematics content to be learnt, students thinking and making sense of mathematics taught, students' participation in meaningful mathematics learning, opportunities be given to them in the class to explain their own ideas and students' thinking to be included in the classroom discourse. The students' level of conceptual understanding is assessed through the use of cognitive levels of Bloom's (1956), revised by Krathwohl (2002) as remembering, understanding, applying, analysing, evaluating and creating.

The researcher's interaction with the participants revealed that CA is the cumulative scores of SBA that are calculated from CA ratio of 15:15:70 from the end-of-term examinations from SSS1, SSS2 and SSS3 to form the 20% scores used by WAEC high-stakes mathematics examinations in WASSCE. Mathematics education scholars (e.g Adeoye, 2010; Alufohai & Akinlosotu, 2016; Obe, 1983; Ojerinde & Falayajo, 1984; Okpala & Onocha, 1994) support the involvement of teachers in the systematic assessment of students' performance as part of teachers' instructional practices. Afemikhe and Omo-Egbekuse (2010) confirm that the senior secondary school students taking the high-stakes examinations are expected to have demonstrated competencies on what they were taught from SSS1 to SSS3. In the SBA, classwork and assignments form 15%, tests form 15% and the end of term examination has 70%, which gives a total of 100% for each term, given in a ratio 15:15:70. These practices are confirmed by

Ojerinde and Falayajo (1984), who stipulate that two CA tests be administered in every school term in addition to an end-of-term examination where the CA and examinations are to be combined in the ratio: 15:15:70. There is a particular formula and accompanying software used by WAEC to moderate the school-based continuous assessment score in the WASSCE. This software moderates the weight score of the candidates' CA scores and the WASSCE scores before arriving at the final scores. Teachers themselves are generally not privy to the formula and the software, which creates suspicion and fuels perceptions of malpractice in CA, real or imagined.

This study found that there were misgivings among the teachers about the reliability that can be conferred on the components of the WASSCE final grades awarded to their students with the inclusion of schools' CA results. The ten teachers had divided opinions on the 20% school-based CA marks sent to WAEC high-stakes examinations to form part of the final scores. Some teachers (Teachers B, E, H and J) were in support, while others (Teachers A, C, D, F, G and I) were against the policy (section 5.3.1 and 5.5). Those in support of the CA argued that this policy was enshrined in the National Policy on Education (FRN, 2004) to complement the students' scores at the end of WASSCE. The teachers opposing the policy argued that the high-stakes examinations are more reliable than the inclusion of CA scores. That is, they preferred pure high-stakes examination scores without the inclusion of school-based CA scores. Adamolekun (1984), Ayodele (2012, 2013) and Omowaye (2002) observe that schools and/or teachers in their assessment practices can and deliberately will inflate the scores and grades of their students to ensure that the students emerge successful, no matter the scores or grades they receive in the final high-stakes examinations. Abass (2000) supports the view that candidates' CA scores may not be the true reflection of their ability as they might be scored higher than their actual ability.

The findings support the earlier statement of Afemikhe and Omo-Egbekuse (2010), who observe that some of the challenges are lack of uniformity in standards for implementing across schools; therefore, there is a problem of comparability of the scores of students from different schools and faking of CA scores that WAEC high-stakes examinations require particularly for the WASSCE. The teachers' scepticism about the CA marks casts

a dark shadow on the professionalism of some of the Nigerian teachers as far as assessment is concerned. More so, the certification policy clearly stated in the national policy on education (FRN, 2004, p. 23) that “The Senior School Certificate (SSC) shall be based on continuous assessment and a national examination.” This policy is directed toward teachers’ instructional and assessment practices and aligns them with the requirements of the classroom and high-stakes assessments.

As mentioned earlier, professional development is one of the opportunities mathematics teachers have in the teaching profession (see section 5.9). When participants were asked whether there is provision for professional development in Kaduna State, they agreed that the in-service opportunities are there for senior secondary school mathematics teachers to further their education through any university of their choice. They also added that workshops, seminars and conferences are always organised. However, the majority of them claimed that they have not had the opportunity to attend any workshop, seminar or conference. The participants were all men, with an appropriate teaching qualification except one that had national diploma (Teacher C) and National Certificate of Education (NCE) (Teacher G) (see Table 5.2). NCE was the minimum teaching qualification for secondary schools at the time the officer was employed, but he did not update his qualification. NCE now is a minimum qualification for teachers of primary schools. The participants in this study had an average of 18 years teaching experience among them. From the data collected on the ten teachers, it was found that there is inadequate financial support for CPD (see teacher G in section 5.9). This finding supports the earlier claim by Ejima and Okutachi (2012) that there is lack of government commitment and the inability of the Teacher Registration Council of Nigeria (TRCN) to regulate the teaching profession.

## **6.5 Conclusion**

The focus of this study was to investigate the effects of high-stakes assessment on mathematics instructional practices of selected teachers in Nigerian senior secondary schools. Specifically, this study aims at examining the effects of WAEC high-stakes examinations/assessments on Kaduna State senior secondary school mathematics teachers’ instructional, preparatory and assessment practices, beliefs about effective

mathematics teaching, and opportunities open to them and challenges they face. The study was a qualitative ethnographic case study whose data were generated through lesson observations, mathematics teachers' interviews and archived documents related to the study. The ethical considerations and the trustworthiness of the study were properly adhered to in the study. The study was underpinned by an integration of the frameworks of Popham (2001, 2003a, 2004) on instructional and assessment practices, Schoenfeld (1992, 2016, 2017a, 2017b) on teaching for robust understanding (TRU) in mathematics and Bloom's (1956) taxonomy of educational objectives as revised by Smith et al. (1996) and Krathwohl (2002).

As earlier discussed in the previous chapters, high-stakes assessments are important to the school system and the entire society. According to the literature (Aysel, 2012; Chales-Ogan & Otikor, 2016; Heubert, 2000; Reynolds et al., 2009; Smyth, E Banks, & Calvert, 2011), high-stakes assessments are mechanisms often used to grade students' performance, first and foremost, and as an indicator of teachers' proficiency and effectiveness in their instructional and assessment practices. They are also used to take decisions on student selection and placement at the next level of education (Aysel, 2012; Chales-Ogan & Otikor, 2016; Heubert, 2000; Reynolds et al., 2009; Smyth, E Banks, & Calvert, 2011). In this study, the high-stakes West African Senior Secondary School Examinations (WASSCE) conducted by WAEC are used to determine students' level of performance for graduation or certification, for selection of students with at least five credits including English language and mathematics and for placement in Nigerian tertiary institutions. This is where students are trained in different disciplines and become future leaders of the country.

High-stakes assessments, specifically WAEC high-stakes examinations, are perceived to be good, objective and homogeneous by some (e.g. Agbeti, 2011), but they can influence mathematics teachers' instructional, preparatory and assessment practices by making them focus on content covered by the examinations. Consequently, the aims of the mathematics curriculum may not be achieved in the teachers' instructional and assessment practices (FRN, 2004). Teachers may be encouraged by pressure from students, principals, parents and other stakeholders to adopt direct teaching methods that

emphasize coaching, drilling students to memorize solution procedures or using examination-driven instruction and other revision practices for the sake of passing the WAEC high-stakes examinations. This may also force students to memorize examinations materials as a learning style and not get them to focus on conceptual understanding, problem solving and critical thinking skills, as emphasized by Popham (2001a). Additionally, these high-stakes assessments could be stressful and can negatively influence teachers' confidence and students' anxiety. The findings of this study confirm that teachers may teach to the test via item teaching rather than curriculum teaching (Popham, 2001a).

Following the discussion, so far one can conclude that WAEC high-stakes examinations have significant effects on the selected Kaduna State senior secondary school mathematics teachers instructional, preparatory and assessment practices in multiple ways. The effect is the extent to which what is assessed determines what is taught in the classroom (Havnes, 2004; Popham, 1987; Teese, 2000). Therefore, it is important to understand the role of high-stakes assessments in Kaduna State senior secondary schools, because they seem to hold the key to closing the gap between the mathematics curriculum and the actual instructional and assessment practices in the classroom. Understanding the influence of high-stakes examinations on the instructional and assessment practices will be valuable in pointing to what has to be done to redirect the effect of high-stakes assessments to become supportive of pedagogically sound instructional practices. It is clear that teachers are supposed to be efficient in their assessment practices by making knowledge accessible to all students and not to be influenced by any high-stakes assessment. They need to act on the belief that all students can learn mathematics and treat students equitably, recognizing the individual differences that distinguish one student from another and taking account of these differences in their instructional practices. However, societal pressure from stakeholders such as parents, principals and even students themselves can lead to violations of sound pedagogical and assessment practices for short term gains at the expense of conceptual understanding.

## 6.6 Contribution to theory and practice

This qualitative ethnographic case study made some significant findings that gave an in-depth understanding of the effect of WAEC high-stakes examinations on mathematics teachers' instructional, preparatory and assessment practices of ten Kaduna States senior secondary schools in Nigeria. The processes and procedures of WASSCE in WAEC high-stakes examinations at the senior secondary school level are designed to ensure objectivity and neutrality. The objectivity and neutrality are with reference to the national mathematics curriculum, WAEC syllabus, teachers' instructional practices, beliefs and classroom CA practices and CA for WAEC's WASSCE. However, WAEC high-stakes mathematics examinations results have a structural effect (that is, five credits including English language and mathematics for candidates to qualify for admission to higher education institutions in Nigeria) in filtering those students who will study different disciplines, such as engineering, medicine, sciences and others.

The findings revealed that the traditional lecture method was used to frantically prepare students for examinations. Lessons presented predominantly were designed to coach, hurry and cover mathematics content that included past examination question papers or examination-type questions from revision textbooks. The drive for students' success in the high-stakes assessments may increase due to pressure from students, parents, principals and other stakeholders with high expectations for student success

With the focus on WAEC high-stakes examinations, mathematics teachers may pay a lot of attention to CA reliability, since it is meant to supplement the scores and the grades of the students. However, teachers may have little understanding of the moderation methods because these methods are not openly discussed with them. This scenario might explain the apparent disenchantment with CA marks in the school system and might also tempt teachers to award arbitrary high scores to generate students' CA scores for grade purpose.

Few studies were found on the effect of high-stakes assessments on mathematics instructional practices in Nigeria and specifically, in Kaduna State. Most studies were generally on assessment practices and CA practices in Nigeria and not on senior

secondary school mathematics teachers' instructional and assessment practices. The few found were studies from the southern part of Nigeria. Hence, this study makes a valuable contribution to knowledge in this field. There are equally few studies on effects of high-stakes assessments on mathematics teachers' beliefs about what it means to teach mathematics effectively in Nigeria. Elsevier Analytical Services (2015) for example, states that Nigeria accounts for only 0.22% of the world's total publications, and even a smaller share of all citations and highly cited articles worldwide. The analyses further observe that Nigeria has low international collaboration rates and a highly sedentary active researcher population. The information implies that Nigeria's research base is very scant or limited to local rather than global appeal. Therefore, this study might be a pioneer work in Kaduna State, Nigeria.

Findings from this study have also added to the body of knowledge about existing instructional and assessment theory and practice within the Nigeria education system and act as a framework for initial teacher education and continuing professional development in handling mathematics classroom instructional and assessment practices. Therefore, the current study has contributed to existing knowledge in mathematics education and other related disciplines.

### **6.7 Implication for policy and practice**

The West African Senior School Certificate Examinations (WASSCE) have such high stakes by virtue of their status as a school-leaving certification process and the role they plays in selection and placement in Nigerian higher education institutions. As mentioned earlier, the preference given to high-stakes assessments in mathematics as a core subject is an indication of accepting WASSCE because of its perceived objectivity and neutrality when compared with similar examination bodies. The effect of such a preference can be seen in the ten Kaduna State senior secondary school mathematics teachers' instructional and assessment practices by relying on the past WASSCE question papers and emphasis given in almost every lesson to the WAEC high-stakes examinations.

Therefore, this study indicated that the opportunity for the mathematics teachers to use modern methods of instruction like group method, student-centre approach, collaborative teaching and learning or team teaching, use of improvised instructional materials, classroom didactic and discourse, amongst others is limited. In this case they have missed out on the global trend of mathematics education and current instructional and assessment strategies. However, the focus is always on student outcomes in the assessed curriculum rather than the prescribed or intended one. WASSCE, with their high-stakes examinations, means that there are consequences for students' success and failure. Those who pass are rewarded and those who fail face the consequences of their failure. It might be useful to rethink the role of CA at policy level to ensure uniformity of assessment tasks and to explain clearly to teachers the moderation procedures so that misconceptions about cheating are dispelled.

### **6.8 Limitations of the study**

This study is a qualitative ethnographic case study of the effect of high-stakes assessments on mathematics instructional practices of selected teachers of Kaduna State senior secondary schools in Nigeria. The study is thus limited in scope and population. It did not involve mixed methods for comparison. Moreover, ethnographic studies usually take at least one year but this study was a micro-ethnography project (Wolcott, 1990) (see section 4.2.4) of three months. It was also a case study (see section 4.2.3) that focused on ten mathematics teachers in the ten senior secondary schools for only senior secondary school 3 (SSS3) students (equivalent to Grade 12 students). This means the findings cannot be generalised to the entire population of Nigerian senior secondary school mathematics teachers. However, the study can be use in theory and practice of education as well act as framework for initial teacher education and continuing professional development in handling mathematics classroom instructional and assessment practices. More so, the study is set in Kaduna State, in Nigeria context, and therefore may not represent other regions in Nigeria or other countries.

However, areas and countries with similar backgrounds may find this research useful. The senior secondary schools were similar in instructional resources (see section 1.12)

and size, there will be variations in findings from other schools with different instructional resources, human resources size and school infrastructure.

This study was conducted in Kaduna State government (public) senior secondary schools; therefore, the private senior secondary schools were not part of this study. The inclusion of private schools could have given a different result. Additionally, conducting research in government schools is sometimes curtailed due to bureaucratic protocols in the granting of permissions. However, permission for the study was granted by the Kaduna State Ministry of Science, Technology, and Education and REC humanities, Stellenbosch University (see Appendices (A and B)).

This study used a non-judgmental approach, therefore, did not give judgmental feedback and comparison to the individual mathematics teacher in their lesson presentation and their responses in the interviews. The aim of the study was to acquire a deeper understanding of the effects of high-stakes assessments on the instructional practices of selected mathematics teachers in Kaduna State (Nigeria) senior secondary schools, their beliefs, and the opportunities and challenges they faced in the context of WAEC high-stakes examinations and CA practices.

## **6.9 Recommendations**

This study makes a number of recommendations from the in-depth understanding of the relevant literature and the findings on the effects of high-stakes assessments on mathematics instructional practices of selected teachers in Kaduna State senior secondary schools in Nigeria. The researcher wishes to suggest that mathematics teachers should use modern methods of instruction like group methods, student-centred approaches, collaborative teaching and learning, use of improvised instructional materials, classroom didactics and discourses to enhance conceptual understanding of senior secondary school students in mathematics as proposed by scholars such as Popham (2001, 2003b, 2004) and Schoenfeld (1992, 2016, 2017).

Although this is not part of this study, the researcher observed that the human and material resources in the selected schools were grossly inadequate. Qualified teachers should be recruited in the secondary schools and government should provide

infrastructure needed for the smooth administration of instruction. Therefore, various incentives should be made available for the teaching profession in order to attract people to the job to reduce the problem of overloading teachers with work. Various mathematics teacher training institutions need to give attention to the aspect of MKfT, especially the PCK. This should be improved upon so as to enable mathematics teachers handle their instructional, preparatory and assessment practices for WAEC high-stakes examinations effectively.

Teachers should change from their traditional method of instructional practices that only emphasize the solving mathematics problems that must give accurate answers. The coaching, hurrying to cover the mathematics curriculum and practising with past examinations questions papers for the high-stakes assessments should be discouraged in the school system. Teachers should encourage and motivate the students to effectively and meaningfully learn mathematics.

Schools instructional facilities were observed to be inadequate (see Table 5.4). Therefore, the senior secondary school mathematics curriculum as a reference document in the instructional practices should be well defined with the procedures strictly adhered to. Adequate and reliable instructional materials and activities will be useful to both the students and the teachers in their instructional and preparatory practices for high-stakes assessments in Nigerian senior secondary schools. Additionally, there was no mathematics laboratory in any one of the ten schools studied. Therefore, mathematics laboratories should be built in the Nigerian senior secondary schools for effective teaching and meaningful learning of mathematics (to concretize the teaching of mathematics). Generally, it is important for policy makers and educational practitioners to ensure that the teachers' instructional practices and the use of CA are monitored continuously for the benefit of students (Goertz & Duffy, 2003).

The senior secondary school teachers, principals and other stakeholders who are interested in arbitrarily faking the school-based CA scores used by WAEC high-stakes examination in the WASSCE should be educated to be aware of the moderation method and its washback effect on the schools and their students. However, there should be a reasonable correlation between candidates' performance in the school-based CA and

WAEC high-stakes assessments. There should be more weighting accorded to the final examinations.

The government and other stakeholders in education should provide computers in the senior secondary schools so that teachers in their mathematics instructional and assessment practices can use them for computer-assisted instruction, as recommended in the national mathematics curriculum (NERDC, 2007) (see section 1.4.6.1). The teachers should also be well trained on how to use the computer-assisted instructional materials in the senior secondary school system. The computer-assisted instruction will facilitate effective teaching and meaningful learning of mathematics. It will also make the teachers and students to meet up with the international standard and best practice in secondary school mathematics. It will also facilitate effective teaching and meaningful learning of mathematics.

One of the greatest challenges faced by any education administrator and school personnel lies in the training and re-training of teachers to enhance the quality of education. Government should regulate the quality of teachers by ensuring coherent in-service training for mathematics teachers in Nigerian senior secondary schools. The Teacher Registration Council of Nigeria (TRCN), the National Teachers Institutes (NTIs); faculties of education, institutes of education, schools of education in polytechnics; the National Mathematical Centre (NMC); and the National Institute for Nigerian Languages (NINLAN) responsible for teachers' professional development should ensure continuous implementation of government-led continuous professional development (CPD) initiatives to relieve teachers of self-funding their participation in private CPD programmes. Government and senior secondary school Principals should show a more positive attitude towards teachers' CPD and encourage teachers' participation in such programmes.

### **6.10 Recommendations for further study**

This study was an exploratory study of the effects of the high-stakes examinations on mathematics teachers' instructional practices in Kaduna State senior secondary schools of Nigeria with reference to WAEC's high-stakes mathematics WASSCE. Therefore, further research may be necessary in terms of the topic of this study. Another study may

be replicated in mathematics or different subject using the same topic or different topic in different locations using any of Nigerian's thirty- six states, any senatorial or geo-political zones of Nigeria or any other country. This will help to give a wider view of this aspect of education and can be compared with the current study.

This study was a qualitative ethnographic case study (see section 4.2.1, 4.2.2 and 4.2.3) where the findings are limited in scope and population and cannot be compared or generalized to the larger population. Therefore, another longitudinal research may be carried out as mixed method research (Creswell & Plano Clark, 2011; Johnson & Onwuegbuzie, 2004; Tashakkori, & Teddlie, 2010) so that the results may be viable for comparison and methodological triangulation (Yin, 2009; Zohrabi, 2013). With the limitations of a case study, another study may be conducted using a large population so that the findings can be generalise to a larger population and over a longer period of time. This may also help to further substantiate or repudiate the current findings as data from a larger sample tends to be more reliable.

It is imperative to know that high-stakes assessments are conducted at all levels of education for decision making (see section 1.1). Therefore, similar studies can be replicated in different levels of education, that is, either at primary school, other classes of senior secondary school, junior secondary school or even tertiary level of education, because this research was on senior secondary schools using only the SSS3.

This study investigated mathematics teachers' instructional and assessment practices. Therefore, this study also suggests that learners, for example, be investigated for the effect of high-stakes assessments on students' learning of mathematics in any developing country context. Most literature on this study was based on studies in the developed world and explicit comparison may not be possible.

The instruments used for this study were lesson observations, semi-structured interviews and archived documents (see section 4.4.1, 4.4.3 and 1.4.6). In conducting a similar study, the researcher should use collaborative lesson study and focus group interviews with teachers and/or students, focusing specifically on certain aspects of the findings from the original study. The suggestions for further research will provide different data than the

current study and may contribute a lot to theoretical and practical understanding of mathematics teachers in in their instructional, preparatory and assessment practices for high-stakes assessments.

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## APPENDIX A: Ethics Approval



### NOTICE OF APPROVAL

#### REC Humanities New Application Form

26 March 2018

Project number: 1179

Project Title: The effect of high-stakes assessments on mathematics instructional practices of selected teachers in Nigerian senior secondary schools

Dear Mr Patrick Bosan

Your response to stipulations submitted on 26 March 2018 was reviewed and approved by the REC: Humanities.

Please note the following for your approved submission:

#### Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
4 October 2017	3 October 2020

#### GENERAL COMMENTS:

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

**If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.**

Please use your SU project number (1179) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

#### **FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD**

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

#### **Included Documents:**

Document Type	File Name	Date	Version
Research Protocol/Proposal	Patrick Bosan's PhD Proposal (Approved copy)	16.08.2017	16/08/2017
Information sheet	Information sheet		17/08/2017
Informed Consent Form	INFORMED CONSENT Form 2017		17/08/2017
Data collection tool	Instruments for research field work 2		17/08/2017
Data collection tool	Observation Instruments		17/08/2017
Default	Application for permission		17/08/2017
Default	Principal perm letter		17/08/2017
Default	Zonal Director perm letter		17/08/2017
Data collection tool	portfolio-ed-infantil		17/08/2017
Data collection tool	description of documents		17/08/2017
Default	RESEARCH PERMISSION		13/02/2018 First

Default	REC APPROVAL LETTER	13/02/2018	First
Default	REC APPROVAL LETTER	11/03/2018	First
Default	Response to REC stipulations -1	11/03/2018	First
Default	CHANGES REQUESTED	11/03/2018	First
Default	RESEARCH PERMISSION	11/03/2018	First
Default	Proof of Zonal Director permission	11/03/2018	First
Default	Proof of Principals' permission 1	11/03/2018	First
Default	Proof of Principals' permission 2	11/03/2018	First

If you have any questions or need further help, please contact the REC office at [cgraham@sun.ac.za](mailto:cgraham@sun.ac.za).

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

*National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.*  
*The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2<sup>nd</sup> Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.*

## APPENDIX B: Approval from Ministry of Education



MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY  
KADUNA STATE, NIGERIA

HED/GEN/S.I/247

24<sup>TH</sup> October, 2017

The Zonal Director  
Kafanchan Zone

### APPLICATION FOR PERMISSION TO CONDUCT A RESEARCH

Letter dated 28<sup>th</sup> September, 2017 on the above Subject matter refers.

2. I am directed to convey approval for Patrick Nefai Bosan of Stellenbosch University South Africa to conduct a research on 'The Effect of high Stakes assessment on Mathematics Instructional Practices of selected Teachers in Nigerian Secondary Schools' in your Zone.
3. Kindly grant him access to the Schools, please.

  
**Habiba C. Kisha**  
AD/HE  
For: Commissioner

*Principal*  
*Ref. to the above matter,*  
*give the officer the needed*  
*assistance and cooperation*  
*please.*  
*By Ag Zonal Director,*  
*30/10/17*

State Secretariat Complex, P.M.B 2017, Kaduna, Kaduna State-Nigeria  
Tel: +234 (0) 818 407 9036 | Website: [www.kdsg.gov.ng](http://www.kdsg.gov.ng) | Email: [education@kdsg.gov.ng](mailto:education@kdsg.gov.ng)

## APPENDIX C: CONSENT FORM



UNIVERSITEIT•STELLENBOSCH•UNIVERSITY  
jou kennisvenoot • your knowledge partner

### STELLENBOSCH UNIVERSITY INFORMED CONSENT TO PARTICIPATE IN RESEARCH

---

#### **The effect of high-stakes assessments on the mathematics instructional practices of selected teachers in Nigerian senior secondary schools**

You are asked to participate in a research study conducted by Patrick Nefai Bosan, M Sc. (Ed) Mathematics, from Department of Curriculum Studies, Stellenbosch University. This research study is part of a PhD programme in Department of Curriculum Studies, Faculty of Education, Stellenbosch University, South Africa. Research results will be disseminated in the formal PhD dissertation, in research papers and at conferences.

#### **PURPOSE OF THE STUDY**

This research project wishes to investigate the effect of WAEC high-stakes assessments on the instructional practices of selected mathematics teachers in Kaduna State (Nigeria) senior secondary schools. Nigeria has high-stakes examinations at the end of senior secondary school (second level of education) that determine entry into higher level of education. One of these examinations is the West African Senior School Certificate Examination (WASSCE) administered by West African Examination Council (WAEC).

#### **9. PROCEDURES**

If you volunteer to participate in this study, I would ask you to do the following things (mark  if applicable):

- to take part in a series of individual interviews.
- to be part of a focus group.
- to be observed while teaching your senior secondary school 3 (SSS3) class(es) – graduating class.
- To be video-recorded during class observation and interviews.

Definitions of terminology:

**Instructional practices:** Are effective teaching of mathematics that established clear goals, situates goals within the learning progressions and use the goals to

guide instructional decisions as well as implementing tasks that promote reasoning and problem solving.

**High-stakes assessments:** Those standardized tests or examinations administered at the end of every level of education (for example, Primary, senior secondary school equivalent to grade 1 to 12) to make significant educational decisions about the pupils/students, teachers and the schools.

## 10. POTENTIAL RISKS AND DISCOMFORTS

The following potential risks/discomforts may arise:

- **Coercion:** the researcher will take special care not to coerce anybody to take part in the study and should anybody decide against participation it will not have any negative consequences for them. Participation will thus be voluntary.
- **Confidentiality:** The researcher will ensure that anonymity and pseudonyms are maintained for all information gained from interviews, reflective journals, observations and other means will be handled in a confidential manner. All information will be stored on a password-protected personal computer, which will be kept in a safe at the researcher's home under lock and key and will be destroyed when no longer needed for the research. Participants real identities will not be disclosed when data is disseminated.
- **Objectivity:** The researcher's role will be clearly demarcated and he will strive to stay objective during the research process. Data will be trianquulated and participants will be encouraged to engage in critical discussions. The researcher will not coach participants to answer in specific ways to influence the data gathered during interviews, questionnaires etc.
- **Power Relationships:** Before data collection starts the researcher will discuss the risks concerning possible power relationships between him and the participants as well as between the participants amongst themselves. Benefits of action research will be explored where all participants and the researcher work collaborative and any decision-making process will have to be agreed upon mutually between the participants and the researcher.

## 11. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

It is hoped that participation in this study will benefit the participants by encouraging them to reflect on the effect of high-stakes assessments have on their instructional practices, and effectively handle challenges in the classrooms and pressure on the time-restricted high-stakes assessment.

## 12. PAYMENT FOR PARTICIPATION

Participation in this research is on voluntary basis. No payment.

## 13. CONFIDENTIALITY

Any information that is obtained about this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by:

- Anonymity will be maintained during data collection.
- Pseudonyms and special coding of data will be used in the final draft of the thesis.
- Notes, interview transcriptions, transcribed notes and any other information that could identify you, will be stored on a password-protected personal computer, which will be kept in a safe at the researcher's home under lock and key.
- Any information gathered from you and transcribed, will be made available to you on request.
- Video-recordings will be always accessible to you. They will be accessible to other participants only if prior consent is obtained from you.
- All information, recordings and materials for this research will be destroyed when no longer needed for the research.
- Information gathered for this research will be used only for the purpose of this research and publications that may result from the research.
- In any publication that may result, no personal details of participants will be used. All materials gathered will be destroyed when no longer needed for the research.
- Information from this research will be made available to the Ministry of Education on request.

#### **14. PARTICIPATION AND WITHDRAWAL**

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and can still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [[mfouche@sun.ac.za](mailto:mfouche@sun.ac.za); 021 808 4622] at the Division for Research Development.

#### **15. IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about the research, please feel free to contact:

Mr. Patrick Nefai Bosan (Doctoral Candidate and principal researcher)  
Tel: +27781077129/+2348034136838  
Department of Curriculum Studies  
Stellenbosch University

GG Cillie Building  
Stellenbosch

Prof Mdu Ndlovu (Supervisor)  
Tel: 0218083484  
Room 3065  
GG Cillie Building  
Stellenbosch University

Dr Faaiz M Gierdien (Co-supervisor)  
Tel:  
Room 4025  
GG Cillie Building  
Stellenbosch University

## 16. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

### SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to \_\_\_\_\_ (*name of participant*) by Mr Patrick Nefaj Bosan in (*Afrikaans/English/Xhosa/other*) and I, the participant, am in command of this language or it was satisfactorily translated to me. I, the participant, was given the opportunity to ask questions and these questions were answered to me.

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

\_\_\_\_\_  
**Name of Subject/Participant**

\_\_\_\_\_  
**Signature of Participant**

\_\_\_\_\_  
**Date**

### SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to \_\_\_\_\_ (*name of the subject/participant*). He/she was encouraged and given ample time to ask me any questions. This conversation was conducted in [*Afrikaans/\*English/\*Xhosa/\*Other*] and [*no translator was used/this conversation was translated into \_\_\_\_\_ by \_\_\_\_\_*].

\_\_\_\_\_  
*Signature of Investigator*

\_\_\_\_\_  
*Date*

## APPENDIX D: OBSERVATION SCHEDULE

### Lesson observation

The following dimensions adopted from Schoenfeld's (2017) "Teaching for Robust Understanding (TRU) framework" which focus on what really counts in powerful learning environments that will make students powerful thinkers, will be considered during mathematics teachers' lesson observation.

The five dimensions of powerful mathematics classroom

#### Dimension 1: The Mathematics Content

The extent to which classroom activity structures provide opportunities for students to become knowledgeable flexible and resourceful mathematics thinkers. Discussions are focused and coherent providing opportunities to learn mathematical ideas, techniques and perspectives, make connections and develop productive mathematical habits of mind.

#### Dimension 2: Cognitive Demand

The extent to which students have the opportunities to grapple with and make sense of important mathematical ideas and their use. Students learn best when they are challenged in ways that provide room and support for growth with tasks difficulty ranging from moderate to demanding. The level of challenge should be conducive to what has been called "productive struggle".

#### Dimension 3: Equitable Access to Mathematics

The extent to which classroom activity structures invite and support the active engagement of all of the students in the classroom with the core content being addressed by the class. Classroom in which a class in which a small number of students get most of the "air time" is not equitable, no matter how rich the content all students need to be involved in meaningful ways.

#### Dimension 4: Agency, Ownership and Identity

The extent to which students have the opportunities to "walk the walk and talk the talk" -to contribute to conversation about mathematical ideas, to build on others' ideas and have others build on them, in ways that contribute to their development of agency (the willingness to engage) their ownership over content and the develop active identities as thinkers and learners.

#### Dimension 5: Assessment practices

The extent to which classroom activities elicit students thinking and subsequence instruction, responds to these ideas, build on productive beginning and addressing emerging misunderstandings, powerful instruction "meets students where they are", and gives them opportunities to deepen their understandings.

Framing each of the five dimensions with questions

### The mathematics contents

What are the main ideas in the lesson?

How does it connect to students previously knowledge?

Can the teachers enrich the task to provide opportunities to grapple with more of them?

**Cognitive demand**

How long will the student think and make sense of things taught?

What happen when the student gets stuck?

Are students expected to give explanation or just to give answers?

What opportunities do students have to make their own sense of mathematical ideas?

**Equitable access to content**

Do students get to participate in meaningful mathematics learning?

Can students hide or ignore? In what way can they be engaged in the lesson?

Who does and does not participate in the mathematical work of the class, and how?

**Agency, ownership and identity**

What opportunities do have to explain their own ideas?

In what ways are they built on?

How are students being recognize as being capable of and able to contribute?

What opportunities do students have to explain their own respond to each other’s mathematical ideas?

**Formative assessment**

How are students thinking included in the classroom discussion?

Do mathematics instructional practices respond to students’ ideas and help them to think more?

What do the teachers know about each student’s current mathematical thinking, and how can he/she build on it? How can the information be used?

**Preparation for the lesson observation**

Teacher: \_\_\_\_\_ Date: \_\_\_\_\_

Please complete as preparation for the classroom observation.

What is the mathematical goal of the lesson? TIP	
What are the students going to do in this lesson? SAP	
What are the new mathematical ideas students will have to connect to what they already know? TC	

What information that you get from today's lesson will assist you in assessing the success of the lesson? TIP	
What are you anticipating students will find difficult? SAP	
How are the students going to react to this lesson? SAP	
Why is today's concept important for future understanding of mathematics? TAP	
Any other things I need to know? TIP	

**Observation guide used for the research**

Code of school: ..... Date: .....

Code of teacher .....Highest academic qualification: .....

Chronological Age .....Highest professional qualification: .....

Teaching experience for the grade/exam class: .... Years: ..... Months: .....

Other subjects taught: .....

Lesson observed: year/Class: .....

Topic: .....

Objective:.....  
.....  
.....

Time	Instructional strategies	Access and participation	Interaction	Classroom enrolment	Students as individual/interdependence

Coding to be used in the instruments

Teachers	Coding
Instructional practices	TIP
Assessment practices	TAP
Accessing students' understandings of concepts	TA
Probes students' understandings	TP
Connect students' understandings	TC
Assessing student' understandings	TAS
Reflecting on practice	TR
Professional development	TPD
Students active participation	SAP

#### Adequacy of key teaching and learning resources in secondary schools

S/N	RESOURCES	NUMBER AVAILABLE	ADEQUATE	INADEQUATE
1	Classrooms			
2	Desk/chairs			
3	Chalk boards			
4	Exercise books			
5	Text books			
6	Instructional materials			
7	Equipped library			
8	Equipped laboratories			
9	No of maths teachers			
10	No of supporting staff			

#### Field notes and video recordings

Below are the things to be included in the field notes:

Teacher.....

Date.....

Time.....

Place of observation.....

Specific facts, numbers, details of what happens at the classroom.

Sensory impressions: sights, sounds, textures, etc.

Personal responses to the fact of recording field notes.

Specific words, phrases, summaries of conversations, and insider language.

Questions about people or behaviours at the site for future investigation.

Page numbers to help keep observations in order.

Archive documents from the participating schools  
Secondary school Mathematics curriculum,  
West African Examination Council (WAEC) syllabus,  
WAEC chief Examiner reports, and  
Sample of WAEC examination question paper.

## APPENDIX E: TEACHER'S INTERVIEW SCHEDULE

### NIGERIAN MATHEMATICS TEACHERS INTERVIEW SCHEDULE.

This interview is designed to find out exactly the way you think, feel, act, value and evaluate yourself in your mathematics instructional and pedagogical practices and preparatory practices for WAEC high-stakes examination. Your responses will be confidential and used only for research purposes. It will be highly appreciated if you respond to each item with utmost sincerity. Thank you.

#### SECTION A DEMOGRAPHIC DATA

Name of Participant.....Sex.....Age.....

Name of school.....

Class(es) taught..... Number of lessons per week.....

Academic qualifications.....

Professional qualification(s).....

Years of teaching experience.....

Professional Development courses/workshops attended. Next to each one, please indicate if/how it changed your knowledge about mathematics/about how to teach mathematics.....

.....

#### SECTION B INSTRUCTIONAL PRACTICES

1. In what ways do students participate in your lesson? (What do they do?) (TIP)

.....

2. Do you encourage them to ask you questions? Give a reason for your answer (SAP)

.....

3. Do you use any textbooks?

If No explain what you use instead of text books (TIP).

.....

If yes, proceed:

Which ones? Explain why.

.....

4. Do you usually give homework? If Yes, how do you correct them (TAP)?

If Yes, how often and what issues? If not, why not?  
.....

5. Do you collaborate with other Mathematics teachers on your instruction practices (TIP)?

If yes, how often and why?  
.....

6. Could you tell me how much time on average do you spend preparing lesson/markings assignments/etc. (TIP)?

7. Could you tell me what teaching methods you use and why you prefer them (TIP)?  
.....

Which instructional materials do you use?.....

8. Could you describe to me a typical classroom setting in the school (TIP)?  
.....  
.....

9. Do you have complete freedom in your choice of teaching methods (TIP)?  
.....  
.....  
.....

10. What are the positive outcomes of your instructional practices in your school/classes (TAP)?  
.....  
.....

11. What are the negative outcomes of your instructional practices in your school/classes (TAP)?  
.....  
.....

**SECTION C: HIGH-STAKES ASSESSMENT PREPARATORY PRACTICES (TAP)**

12. How do you assess students in your class? When, how often, using what?  
.....  
.....

13. What is your general opinion about the exam system in Nigeria (like WAEC)?  
.....  
.....

14. What strategies do you use to prepare students for the Mathematics WASSCE?  
.....  
.....

15. How does the exam system influence the way that you teach?  
.....  
.....

16. How does the exam system influence the way your students learn or study?

.....  
.....  
17. (a) How do the exam system influences your students' attitudes to mathematics?  
(b) Is the influence positive or negative?  
.....

.....  
18. How often do you refer to the exam during instruction in the class?  
Every class ( ) Every week ( ) Every month ( ) Every term ( ) Only before the exam ( )  
Others. Why?  
.....

.....  
19. What kind of assessment methods do you use in your classes? Why?  
.....

.....  
20. What value to you see, if any, in discussing topics that will not be examined?  
.....

.....  
21. To what extent are the school curriculum and WAEC syllabuses aligned?  
.....

.....  
22. If you were writing a new syllabus, what topic(s) would you include/omit and why?  
.....

.....  
23. Do you cover every topic in the syllabus? Explain your answer.  
.....

.....  
24. For the exam-year classes, when do you finish teaching the course? Why?  
.....

.....  
25. Could you tell me how much time you spend on revision for exam-year classes?  
.....

.....  
26. What study methods/habits do you encourage your students to use?  
Reading texts/notes ( ) Practicing questions from textbook ( ) Practicing old exam questions ( )  
) Memorizing ( ) Understanding underlying concepts ( ) Other

27. How much time do you encourage your students to spend studying Mathematics after normal classroom activities? Why?

28. What is your opinion on WAEC's uses of the continuous assessment (CA) sent to them as part of students' total scores?

29. What are the similarities and differences between the secondary school mathematics curriculum, WAEC syllabus and the Unified Tertiary Matriculation Exam (UTME) Mathematics syllabus?

30. Do you think the Mathematics that you teach in your class is enough for the UTME? Explain your answer.

.....  
.....

31. Do you Practice the past WAEC/UTME questions with the students in the class? If yes, why?

.....  
.....

32. What is your opinion on extra-mural classes/extra lessons for WASSCE/UTME?

.....  
.....

33. Are they necessary, despite the instruction and the preparation you make with students in the school? Explain your answer.

.....  
.....

34. Do they have any impact on the students' performance?

.....  
.....

35. Could you generally comment on your classroom instructional practices on your effort to cover the curriculum/syllabus and successfully prepare the students for WASSCE/UTME?

.....  
.....

36. What types of PD programs are available for mathematics teachers (TPD)?

.....  
.....

**CLOSURE**

Thank you once again for your time. I will keep in touch with you to verify that I have correctly recorded the issues we have talked about today.

## APPENDIX F: TEACHER'S INTERVIEW TRANSCRIPTS

The questions selected for the interviews were about the description of a typical senior secondary school mathematics class; instructional and assessment practices; views on the WASSCE high-stakes examinations system and its influences on instructional practices. The ten participants in the ten Kaduna State senior secondary schools were interviewed about their instructional practices, preparatory and assessment practices find out how these practices are influence by high-stakes assessments and to verify whether what they said was their actual practices during lesson observations.

The first thing the researcher inquired from in the teachers' interview was whether they use the national mathematics curriculum as their working document and its content compared to the WAEC syllabus. The participants responded that they are using the senior secondary school mathematics curriculum together with examinations past question papers in their instructional practices. Teacher A said,

*A teacher is neither a slave to the curriculum nor to teaching methods. We follow the content of the curriculum and we break the content into scheme of work for use in our daily lessons. Although, I use the curriculum alongside some WAEC and NECO examination past question papers.*

Teacher E said:

*The curriculum is my working document in the school. I normally break it into scheme of work so that I will easily know the topics I will teach in the week and plan my lessons at the weekend.*

This confirmed what the participants were doing during their lessons. Using the curriculum alongside the past examination question papers shows that they are influence by the high-stakes assessments in their instructional practices (see section 5.3.1).

It was inquired from the respondents whether there is similarity between the mathematics curriculum and the WAEC syllabus. They agreed that the WAEC syllabus is an off-shoot of the National mathematics curriculum. Some of them responded as follows:

Teacher A:

*The school is operating with the national mathematics curriculum which is in line with the WAEC syllabus. And I sometimes do not cover all topics in the curriculum because of time constraints like frequent holidays, strikes, ethnic/religious conflict.*

Teacher H:

*The national curriculum is the same with the WAEC syllabus. I used them concurrently in preparing my scheme of work each term and in planning my daily lessons.*

When the participants were asked whether they have freedom of choosing their methods of teaching and the type of instructional strategies they use. From their responses it shows they have freedom to choose any method of teaching they want. For example, these were some of their responses:

Teacher A:

*One can use any method provided that the method focuses on understanding of important and relevant mathematical concepts from the mathematics curriculum.*

Teacher B: *I use methods that suit the topic I taught to my students. And our principal always emphasized that we use the appropriate method that will make the students understand the mathematics taught to them and ensure that the students perform well in the WASSCE [West African senior school Certificate Examination]. You know, the school and we the teachers have an image to protect. Although, I have observed that the teaching of SSS3 (senior secondary school 3) has become examinations affair.*

Teacher H:

*I choose my method of teaching. The mathematics curriculum and the WAEC syllabus are the road map that guides me in my teaching. I break the mathematics curriculum into scheme of work for each term so that the work will be easy for me. I follow the topic strictly in order to help the students pass their examinations.*

The responses from Teacher A, B and H informed the study that the national mathematics curriculum and WAEC syllabus are similar in content. The documentary analysis of the national mathematics curriculum and the WAEC mathematics syllabus also give a similar view. Additionally, when teacher B mentioned that they have an image to protect show how some of the teachers' instructional practices are influence by WAEC high-stakes examinations.

For the type of instructional strategies teachers use in teaching the students, the participants responded that they use lecture, demonstration, discussion and inductive method, and questioning techniques. Below were some of their responses:

Teacher H:

*I use whole group instruction, questioning techniques, and lecture and demonstration method. But most of the time I use lecture method to enable me cover much from the syllabus before WAEC examinations in June 2018. Sometimes there is no time for other methods because they waste my time.*

Responses from the interviews confirmed the types of instructional strategies the participants used during the lesson observations. The lecture method, teacher-centred instruction, textbook-bound and use of past examination question papers are strategies to hurry and coach the students to pass the high-stakes assessments. These are the instructional strategies Popham called teaching to the tests as examination-driven

instruction that may not lead to students' conceptual understanding (see section 3.2.1). For example, Teacher E stated that:

*Out of pressure on us from students, principals, parents and others stake holders about this WAEC high-stakes examinations rushing the teaching. For example, some politicians will be telling us to make sure their wards or children pass the WASSCE. We end up rushing the teaching of students toward the WASSCE by using past examination question papers in the class as examples, classwork and assignment. Personally when setting the end of term examination I always pick the questions from the past WASSCE question papers.*

Teacher H said:

*I emphasized on WAEC's WASSCE to my student in the class during teaching to protect my image and that of the school. So that when the students perform well in the examinations, the glory also come to me that I have taught the students very well.*

The participants were asked about the types of instructional materials they used during their instructional practices. They responded that they used the recommended textbooks like New General mathematics for SSS1, 2, and 3 by Channon, J.B., et al; Further Mathematics by Egbe, F., et al textbooks; General mathematics revision textbooks for SSCE and UTME; New concept mathematics and other revision, Basic concepts in mathematics for WAEC, NECO and UTME; Mathematics Association of Nigeria (MAN), comprehensive mathematics revision for SSCE; and questions and answer in mathematics textbooks. The past question papers and other instructional materials like mathematics instruments, cardboard papers, graph board and graph sheets, cards, coins, etc. Teacher J commented that:

*These revision textbooks helped me very well in the teaching of mathematics as a novice in mathematics. Thy also help me in preparing the students toward their final examinations – the WASSCE, SSCE and UTME. I make sure they practice and follow the procedures that will give them the accurate answer as in the past examination marking scheme.*

It was inquired on how the participants engaged their students in their instructional and assessment practices. They said that the students are engage by listening attentively, doing the assigned work, in the class, showing enthusiasm for work by taking initiative to answer and posed questions (see section 5.3.1). The participants also responded that they normal advised the students to spend quality time reading their textbook, notes, practising questions in the textbooks and past questions papers, memorized the questions for the examinations and trying to understand the underlying concepts in mathematics. For example, Teacher A said,

*For the students to equip themselves very well for examinations, they need to spend quality time reading their textbook and their notes, practising questions in the textbooks and past questions papers, memorized the questions for the examinations and trying to understand the underlying concepts in mathematics.*

This advice of Teacher A is contradictory, it is good to advise the students to study well but the issue of memorizing the past question papers negate Popham and Schoenfeld principles of teaching for conceptual understanding and sense making in mathematics.

The participants were asked whether they make professional collaboration by sharing ideas with other mathematics teachers. They responded that they share ideas with colleagues within and outside the school. Teacher A explained that they collaborated with each other especially during WASSCE marking on issues relating to instructional and assessment practices. He said,

*In fact, we always discuss intensively during coordinating and marking of May/June WASSCE on issues concerning the mathematics curriculum, WAEC syllabus and how WASSCE questions are designed. We also share ideas on how to effectively teach the students to pass mathematics and confidently face the classroom challenges.*

Teacher D also said they collaborate with each other's especially during WASSCE marking on issues relating to instructional and assessment practices. He said,

*I mark and supervise WAEC and NECO examinations. We always discuss and come up with alternative ways of approaching WAEC or NECO questions during coordinating and marking of May/June WASSCE and July/August SSCE. We also share ideas on the standard of the questions and whether the questions are correctly set by the examiners or not and make suggestions for improvement in mathematics teaching and learning.*

Teacher C said,

*We make consultations when we sometime have difficulties in some topics in the syllabus or forget how to solve some questions in mathematics.*

. Teacher I said,

*I contact my colleagues in teaching mathematics, if the need arises to discuss matters concerning the teaching of mathematics such as difficulty in teaching some topics in the curriculum and difficulties students have in answering some questions in the standardized examinations.*

Advising each other to always do what that is expected of them in their instructional practices and teaching the students for conceptual understanding is emphasized by Popham (2001, 2003) and Schoenfeld (2017), and use the style of the WAEC high-stakes examination marking scheme as a guide in their revision practices. This is because the scheme of marking contains as many possible correct solution methods and where learners produce further correct solution paths these are added to the memorandum of marking. WAEC called such alternative solutions aliter in the WASSCE marking scheme.

They were asked how they prepare the students for the WAEC high-stakes examinations and how such instructional and preparatory practices are influence by the examinations. The strategies the used in preparing the students for the WASSCE are the use of mathematics textbooks, past examinations question papers during lessons as examples,

for assignment and tests and frequent emphasis to the students on the high-stakes examinations in almost every lesson. The examinations motivate them to teach for the students to be successful in the high-stakes examinations.

Teacher C said,

*My teaching is focused on the WAEC and NECO examinations the students write annually May/June and July/ August of the year, respectively. I use past examination question papers to teach my students so that they can perform excellent in both the internal and external examinations.*

Teacher B said:

*It is very important to always remind the students frequently about the forthcoming examinations in May/June 2018 and teach them toward the examinations. This reminder will always make them know that they have a task ahead of them. In addition, I always have problem of time constraints in trying to explain some difficult concepts that students do not understand in my lesson. In such cases I do refer them to the recommended textbooks and also advise them to study in groups with their classmates to share ideas.*

Teacher I said:

*The examinations influence my method of teaching. Most of the questions I solved with the students in the classroom are always similar to the ones that are set the examinations. It is also very important to cover the syllabus before the students start any standard examination.*

Teacher C said:

*I have to define and explain concepts, give examples and show students can use the shortest and quickest way possible of arriving at the solution to mathematics problems and other possible solutions to mathematics questions. I also allow them to copy examples that will help the students do their class work, assignments and practice past examination question papers.*

Teacher H said:

*Examinations influence me on what to teach and how to guides the students on how to attempt the examinations questions. I direct my instructional practices toward examinations and constantly revised past examinations question papers.*

The high-stakes examinations influence the teachers in their instructional practices by using examination driven instruction explained by Popham (2003 and Julie (2016).

The participants were also interviewed on how much time they take to prepare the students. As earlier mentioned (section 1.4) Nigeria senior secondary education operates three terms annually. First term starts from September to December, second term from January to April and third term from May to August. The SSS3 students write their

WASSCE in the third term. According to Teacher J, he teaches the SSS3 students in the first, second term and do some revisions with the students against the May/June WASSCE. He explained,

*I normally cover the content of the curriculum by the end April and make thorough revision with the students in preparation for WAEC examinations. The third term is virtually left for student revision. Except, in cases, where the school calendar is interrupted by unforeseen circumstances like the last ethnic/religious crisis that took place in November to December 2016 in Southern Kaduna where schools were closed for sometimes because of insecurity in the area.*

Participants were asked of the strategies they use in assessing their students. They said they use varieties of assessment strategies. They use questioning techniques, give the students classwork, the take-home assignment (see section 5.3.1) and tests or examinations. Teacher B responded that:

*Teachers' achievement of objective(s) of the lesson is showed from the students' responses to questions in the class and performance in classwork assignments, tests or examinations.*

The participants were interviewed whether the extra mural/extra lessons necessary in preparation for high-stakes examinations. Extra mural or extra lessons are informal lesson organised in Nigeria by schools, groups or individuals to coach students in preparation for high-stakes examinations like the WASSCE, SSCE, NABTEB, UTME, amongst others. Teacher C explained:

*The extra lessons have an impact on the students' performance. An effective and well organised extra lesson can teach mathematics topics that we the senior secondary school teachers in the school system were unable to cover and students can have opportunity to prepare more for the WAEC or NECO examinations.*

Teacher B said:

*I see it necessary if parents and the schools see the need of allowing their children or students to attend such classes. Yes, in some areas the school time is not enough for teachers to cover the curriculum, more so, there are sometimes disruption of classes in the school calendar because of public holidays and sports activities like inter house or inter schools' competitions, among others.*

This section focusses on the effect of high-stakes assessment on teachers' beliefs about what it means to teach mathematics effectively. It is concern about how high-stakes assessment influence mathematics teachers' beliefs in their classroom instructional and assessment practices.

During the first meeting and interviews with the participants the researcher had an introductory conversation where he asked them their general view and beliefs about teaching mathematics in the senior secondary school. They expressed different beliefs about what it takes to teach mathematics effectively in relation to the influence of high-

stakes assessments. Teacher C expressed a belief that an effective mathematics teacher has passion for the subject. He elaborated that:

*As mathematics teachers in the senior secondary school one need to have interest and commitment as regard to effective teaching and meaningful learning of mathematics. The teaching should also be done toward students' success in examinations like WAEC and NECO.*

Teacher D expressed a belief that an effective mathematics teacher should be patient during his/her instructional practices, understands the students' anxiety on the subject. He was teaching in a girl's secondary school. This is what he said,

*These students have concluded that mathematics is a very difficult. Had it been that mathematics is not a core subject in the school and in the WAEC and NECO majority with not offer it. To encourage these female students to give attention to the class and one has to be patient with them and also handle them like his biological children.*

From our interaction, teacher J expressed a belief that an effective mathematics teacher must be committed to the subject. He said,

*But in my case, I am just starting, and I am the only teacher teaching mathematics the three senior secondary school classes [the SS1, SS2 and SS3]. Sometimes I have to give more attention to the SS3 who write the WASSCE and NECO from May to August, annually.*

Teacher A in his beliefs practices ask his students questions during the lesson, giving them classwork, take-home assignments and tests/ examinations, and made sure students' work is marked and corrections are done. The strategies he used in preparing the students for the WASSCE were the use of past questions papers during lessons as examples, for take home assignments and tests. He said:

*During lesson I make sure I explain the concepts to the understanding of the students, ask his students questions during the lesson, giving them classwork, take-home assignments and tests/ examinations, and made sure students' work is marked and corrections are done. I also prepare my students for the WASSCE using past questions papers during lessons as examples, for take home assignments and tests. The way questions are asked in the past examinations give me a clue on what and how to teach the students. In fact, in this senior secondary school classes our instructions focus on the final examination the students are taking at the academic session [WAEC examination is conducted in May/June and NECO is conducted in July/August].*

This showed that the teacher A used examination driven instruction and high-stakes examinations influence his beliefs practices.

Participants were asked to describe a typical Kaduna senior secondary school classroom. Almost all of them said that teacher is teaching the students and the students are engaged in the lessons by listening attentively, doing the assigned work and asking questions for clarification. According to Teacher G, a typical classroom setting is:

*Students sitting in rows and columns of desks and benches facing the teacher writing on the blackboard. The teacher writes the topic on board and ask the students questions on the previous taught. After that, he introduced the topic of the day. Explain the concepts, give examples, give classwork and move round the classroom marking and correcting the student and conclude by giving the students assignment.*

In conclusion, all of the above point to the strong structuring effect of how high-stakes assessments influence mathematics teachers' beliefs on effective instructional practices.

## **Challenges**

The researcher tried to know the problems the participants are facing as regard to their assessment practices. They mentioned pressure from various quarters with respect to the High-stakes examinations and problems arising from CA practices. Some of the participants gave their responses as follows:

Teacher A: *In this our work we are facing challenges such as pressure from students, principals, parents and other stakeholders regarding students' success in the high-stakes assessments. This pressure does not warrant to follow the normal classroom practices.*

Teacher B said,

*The examinations organized in Nigeria are too demanding and overstressing the teachers teaching the [senior secondary school 3] SS3 and other school responsibilities like compiling of continuous assessments [CA], supervising and invigilating both internal and external examinations.*

Teacher A also lamented that one of the problems he faced in the mathematics classroom was the students' inadequate communication ability in the language of instruction. He said,

*If you define and explain concepts with examples, when you pause and ask them questions to know whether they understand you or not, nobody responds. You discover during classwork that some of them understood you, but how to express themselves in the English language is the problem.*

The opinions on the 20% CA score send to WAEC as part of the total score in the WASSCE sought. Some of the participants (Teacher A, C, D, F, G and I) abolished because some schools always fake those scores while others (Teacher B, E, H and J) said the system should be maintain because it is in the Nigerian national policy on education. They also confirmed that the school base assessment is 15:15:70, that is, 15% for classwork and assignments, 15% for tests and 70% for end of term or year examination. Teacher A said:

*I compile the 20% CA for our school to be given to WAEC, supervise and mark the WASSCE high-stakes examinations. I wish to suggest that WAEC should abolish that CA system. I will sincerely compile our students CA scores while other schools will fake high*

*CA scores and take to WAEC. Some of these CA scores schools send to WAEC do not give a true reflection of their students' performance. I am contesting again it seriously.*

Teacher D said the CA send from schools to WAEC as part of the total score in the WASSCE should not be used because he does trust the score send from schools. He further said,

*WAEC should only determine the students' performance from their WASSCE scores only and therefore, should not use the CA because some centres sent fake scores that do not give a true performance of the students. At the examination period WAEC should strictly supervise all the centres because there are very good in examination malpractices and they are so-called magic centres.*

Teacher E said that the CA policy is enshrined in the Nigerian nation policy of education. He emphasized that,

*The examination system in Nigeria is alright, well organised but the examination ethics need to be reviewed,*

Teacher G said: *I am not in support of that CA that is sent to WAEC because it does not reflect the true performance of the students in some senior secondary schools, especially the private schools. The private schools operate to maximize profit; therefore they inflate CA scores so that all their candidates will pass the examinations.*

Mathematics teachers' professional development (PD) in this study was regarded as one of the opportunities that teachers have in the teaching profession. Participants explained that there is provision for teachers to further their education at any university of their choice through in-service training. Workshops, seminars and conferences are always organised, but sometimes principals are not ready to sponsor their teachers to attend. For example, Teacher I said:

*My principal has been encouraging me to go back for my master's degree that he will recommend me to the Kaduna State Ministry of Science, Technology and Education for the in-service.*

Teacher G said,

*Teachers can further their education through the so called in-service because the teachers go for studies are not sponsored by the government. School principals and government do not encourage teachers through financial assistance to attend workshops, seminars and conferences.*

Two things have remained constant throughout my career: my wish to understand mathematical thinking, teaching, and learning in ways that would support as many students as possible in becoming powerful mathematical thinkers and problem solvers, and my desire to be as "close" to those phenomena as possible, in order to best understand and support them (schoenfeld, A. H. 2016, p. 17).

## APPENDIX G: LESSON OBSERVATION TRANSCRIPTS AND CODING

### FIRST VISIT

The baseline visits, where the researcher met with the participants for the first time in the classroom for the lesson observations. These visits were also to help in increasing the relationships and the rapport with the schools and the participants and start the actual lesson observations.

TRANSCRIPTION	CODING
<p><b>Lesson observation: Teacher A</b></p> <p><b>TOPIC: Modular arithmetic</b></p> <p>The teacher introduced the lesson with questions on the previous class held. This connected the students' interest to the lesson of the day. The teacher defined and explained with examples the concept of modular arithmetic. He said,</p> <p><i>Modular arithmetic is concerned with a basic cycle with the correct number of steps. For example, 5 mod means that a cycle has 5 steps and the principle is where in the cycle one would end. Another example is <math>4 \oplus 24</math> means that you are on the 4 in the cycle and then you go 4 times around the cycle because <math>24 = 4 \times 6</math>. Then you end at 4 again in the cycle. Therefore, the answer is <math>4(\text{mod } 6)</math>.</i></p> <p>One of the student said,</p> <p><i>Sir, my problem is how to follow the cycle and write down the remainder in the mod.</i></p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p>An operation <math>\oplus</math> is defined on the set <math>X = \{1, 2, 3, 5, 6\}</math> by <math>m \oplus n = m + n + 2 \pmod{7}</math> where <math>m, n \in X</math>.</p> <p>(iii) Draw a table for the operation.</p> <p>(iv) Using the table find the true set of:</p> <p style="margin-left: 20px;">I. <math>3 \oplus n</math></p> <p style="margin-left: 20px;">II. <math>n \oplus n</math> <span style="float: right;">WAEC, 2015, question 11(c)</span></p> </div> <p><b>Reflection:</b> used traditional method, questioning techniques, blackboard illustrations. no instructional materials except the lesson notes. The teacher in his instructional and assessment practices focused on teaching procedure and meaning of concepts, tasks focus on understanding important and relevant mathematical concepts, processes, and relationships, create an environment that helped students made sense of the concepts that they were expected to learn, and classroom interactions reflect a productive working relationship among students. There was good</p>	<p><b>TIP</b></p> <p><b>SAP</b></p> <p><b>TR</b></p>

classroom management. Students were picked one at a time from raised hands to ask or respond to any question in the classroom.

### Teacher B

He prepared his lesson on multiplication of matrices a whole class instruction using lecture method. The teacher defined matrix,

*A matrix is a rectangular array of numbers that are enclosed within brackets.*

For example,  $\begin{pmatrix} 1 & 2 & 3 \\ 3 & 5 & 6 \\ 7 & 4 & 8 \end{pmatrix}$  is a 3 x 3 matrix.

He further explained to the students that,

*When we write down the order of a matrix, we first write the number of rows (the horizontal) and then the number of columns (vertical). This is similar to writing down the coordinates of a point. If we multiply two matrices A and B by each other, we multiply each entry of the first row of A with each entry of the first column of B and add the products. That gives us the first entry of the product of the two matrices. Then, we multiply each entry of the second row of A with each entry of the first column of B and add the products. That again gives us the second entry of the product of the two matrices.*

He also explained that,

*The transpose is obtained by interchanging the row and columns of the matrix*

The teacher solved two examples and gave the students some class work.

$$\text{Let } A = \begin{pmatrix} 1 & 4 & 3 \\ 2 & -3 & 4 \\ 5 & 0 & 1 \end{pmatrix} \text{ and } B = \begin{pmatrix} 3 & -1 & 2 \\ 4 & 1 & 3 \\ 2 & -3 & 5 \end{pmatrix} \text{ and } C =$$

$$\begin{pmatrix} 1 & 3 & 0 \\ 4 & -2 & -1 \\ 3 & 1 & -2 \end{pmatrix}$$

Find (1) AB (2) AC. Find the (1)  $AB^T$  (2)  $AC^T$

$$A = \begin{pmatrix} 1 & 4 & 3 \\ 2 & -3 & 4 \\ 5 & 0 & 1 \end{pmatrix} \text{ and } B = \begin{pmatrix} 3 & -1 & 2 \\ 4 & 1 & 3 \\ 2 & -3 & 5 \end{pmatrix} \text{ and } C =$$

$$\begin{pmatrix} 1 & 3 & 0 \\ 4 & -2 & -1 \\ 3 & 1 & -2 \end{pmatrix}$$

Find (1) AB (2) AC. Find the (1)  $2) AC^T) AC^T$

TIP

TIP

TAP

<p><b>Reflection:</b> The teacher focused on students' procedure and meaningful learning. It was difficult for the teacher to assess and connect students understanding of multiplication of matrices in his instructional practices, especially entries with negative sign. Although, the interactions in the classroom reflect a productive working relationship among students. With more explanations the teacher later, probe and connected the students' understandings. The students were passive listeners and were only copying the solved questions from the blackboard. No instructional materials, accept his lesson note book and blackboard illustrations partially achieved.</p> <p><b>Teacher C</b></p> <p>The lesson was on simultaneous linear equations. The teacher explained, <i>Simultaneous linear equations can be solved using substitution, elimination, graphs and matrix method. But we will use the first three methods. The questions I have picked for this lesson are similar to WAEC examination questions you should expect in June exam. For simultaneous linear equations, two linear equations with two variables, say, <math>x</math> and <math>y</math>, then, there is only one value of <math>x</math> and one value of <math>y</math> that will make them balance or true at the same time. Also, each one of these equations can be represented by a straight-line graph and where these two lines intersect (I mean cross each other) represents the value of <math>x</math> and of <math>y</math> (I mean coordinate of <math>x</math> and <math>y</math>) that will make them balance simultaneously.</i></p> <p>The teacher solved some examples using the elimination and substitution methods.</p>	<p><b>TR</b></p> <p><b>TIP</b></p>
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<p>Solve equation: <math>3x - 2y = 24</math> and <math>4x - 9y = 36</math>.</p> <p>Solution:</p> $3x - 2y = 24 \quad (1)$ $4x - 9y = 36 \quad (2)$ $\times 4: 12x - 8y = 96 \quad (3) \quad \text{Or } \times 9: 27x - 18y = 216 \quad (3)$ $\times 3: 12x - 27y = 108 \quad (4) \quad \times 2: 8x - 18y = 72 \quad (4)$ <p>Therefore, <math>x = \frac{12}{19}</math>, <math>y = -\frac{144}{19} = 7\frac{11}{19}</math></p>	<b>TAP</b>
<p>He later said,</p> <p style="text-align: center;"><i>In answering any question in any examination, always use the method that is easier at your disposal. You know you will be working with time.</i></p>	
<p>He then continued with solving questions on quadratic equation simultaneously.</p>	<b>TIP</b>
<p>Solve for X:</p> <p>1 (a) <math>x - \frac{x+3}{x} + \frac{3}{x} = 5</math></p> <p>(b) <math>x + 5 + \frac{12}{x-2} = 0</math></p> <p>2. (a) Solve for p, if <math>p + \frac{40}{p} = 14</math></p> <p>(b) Now use your answer in (a) to solve for x, if <math>x^2 - 3x + \frac{40}{x(x-3)} = 14</math></p>	<b>TAP</b>
<p>Teacher C used traditional method, blackboard illustrations and a revision textbook for High-stakes examinations throughout the lesson. He focused on procedural and algorithmic thinking toward high-stakes examinations but encouraged the students to think beyond the immediate problem and make connections to other related mathematical concepts. The students were passive listeners. partially achieved because there was no enough time to</p>	<b>TR</b>

<p>teach simultaneous linear equations, and simultaneous linear and quadratic equations at the same time.</p> <p><b>Teacher D</b></p> <p>The planned lesson was on simple and compound interest. The teacher explained the concepts of simple and compound interest. He explained:</p> <p><i>Simple interest is calculated at the end of period of savings while in compound interest, the interest is calculated annually. The formula for simple interest is <math>I = \frac{P \times T \times R}{100}</math>, where <math>P</math> = principal, <math>T</math> = time pa and <math>R</math> = rate.</i></p> <p><i>Compound interest is <math>A = P \left( 1 + \frac{r}{100} \right)^n</math> where <math>A</math> = amount, <math>P</math> = principal, <math>n</math> = time and <math>r</math> = rate.</i></p> <p>The teacher solved some examples and gave the students some questions to solve in class. The questions below was solved as examples to the students.</p>	
<div style="border: 1px solid black; padding: 10px;"> <ol style="list-style-type: none"> <li>1. A man bought a Toyota carina at ₦1, 500, 000 and sold it after 4 years at ₦900, 000. What is the rate at which the car depreciated?</li> <li>2. A television was purchase at ₦25, 000, it depreciated by 20% annually. What was price of the television after 3 years?</li> </ol> </div>	<p>TIP</p> <p>TC</p> <p>TAP</p>
<p>Teacher D used the traditional method, blackboard illustrations and new general mathematics 3 for the lesson. His instructional and assessment practices focused on effective teaching and meaningful learning of mathematics. He probed and connected students' understandings. Students were to complete the classwork at home. The objective of the lesson was achieved.</p>	<p>TR</p>
<p><b>Teacher E</b></p> <p>The lesson of the day was on measures of central tendency (mean, median and mode). He employed the lecture method, WAEC past questions paper and blackboard ruler for drawing during instruction. The teacher defined the three terms with examples. He defined and explained,</p> <p><i>Mean is arithmetic average, that is, the sum of data divided by the number of data. When we arrange the data from the smallest to largest value, the middle data is the median. While mode is the data point with the largest frequency.</i></p> <p>The teacher solved two questions on mean from the past question papers as examples, how to present raw data in frequency tables and calculate the</p>	<p>TIP</p> <p>TIP</p>

mean. He did not solve the questions to the final answer. He always allowed the students to complete solving the questions. The teacher told the class, *I am not interested in the answer but your understanding of procedure that will lead to the correct answer. If you understand the procedures in solving problems, I know you will arrive at the correct answer.*

The students were given a question to solve in class and he later added two questions to the students' take-home assignment.

The weight (in kg) of contestants at a competition is as follow:

65 66 67 66 64 66 65 63 65 68  
 64 62 66 64 67 65 64 66 65 67  
 65 67 66 64 65 64 66 65 64 65  
 66 65 64 65 63 63 67 65 63 64  
 66 64 68 65 63 65 64 67 66 64

- (c) Construct a frequency table for the discrete data.
- (d) Calculate, correct to 2 decimal places, the:
  - (ii) Mean

Weight (x)	Frequency (f)	fx
62	1	62
63	5	315
64	12	768
65	14	910
66	10	660
67	6	402
68	2	136
	$\Sigma f = 50$	$\Sigma fx = 3,253$

$Mean = \frac{\Sigma fx}{\Sigma f} = ?$  WAEC 2016, question, 9(a)

Teacher E focused on procedures and meaningful learning, and emphasis on high-stakes assessments and use revision practice. He used, traditional method during instruction. He also used WAEC past questions paper and blackboard ruler for drawing during instruction. There was effective classroom management and control despite a large class size of 65

**TC/TAC**

**TAP**

**TAC**

**TIP/TC**

**TAP**

**TR**

<p>students. He could not get access to individual students because the classroom was very congested. The objective of the lesson was achieved.</p>	
<p><b>Teacher F</b></p>	
<p>The teacher prepared a lesson on ratio and adopted the lecture method. The teacher defined and explained the concept of ratio using real life situations and later solved some examples from the textbook he was using. He explained,</p>	
<p><i>You can recall that to express <math>\text{R}25,000:\text{R}15,000:\text{R}10,000</math> in its lowest ratio is 5:3:2, since <math>\text{R}5,000</math> is the common factor of the three values. If John, Peter and Samson shared <math>\text{R}1050</math> in ratio 6:7:8, what will be Samson's share? To solve this, we first get the sum of the ratio <math>6+7+8 = 21</math>, then Samson's share is <math>\frac{8}{21} \times \text{R}1050 = \text{R}400</math>.</i></p>	TIP
<p>After solving some questions with the students, he told them to take note of the procedures used in solving problems relating to ratio.</p>	TIP/TC
<p>The students were just copying what the teacher was writing on the blackboard. Throughout the lesson the teacher solved all the questions picked from his textbook without finding out whether the students understood. The students were passive listeners. No class activities and no homework or assignment was given to the students. The teacher used teacher-centred, lecture-based and textbook-bound method in his instructional practices. The objective of the lesson was partially achieved.</p>	TR
<p><b>Teacher G</b></p>	
<p>The lesson was on quadratic equations - completing the squares. The teacher used the lecture method in his instructional approach. From the topic he explained, <i>A quadratic equation is an algebraic equation with a mathematical phrase that contains ordinary numbers, variables (such as <math>x</math>, <math>y</math> or <math>c</math>) and operators (such as add, subtract, multiply, and divide). For example, <math>x^2 + 8x + 16 = 0</math>. The equation can be factorised as <math>(x + 4)^2</math>.</i></p>	
<p>He further explained that to factorise a quadratic equation, one can use direct factorization, completing the squares or using quadratic formula, <i>But today we are using completing the squares method. For example, solve the quadratic equation <math>x^2 + 18x + c = 0</math>. To find <math>c</math>, half of the coefficient of <math>x</math> will be 9 and squared as <math>(9)^2 = 81</math> for the equation to become <math>x^2 + 18x + 81 = 0</math> where <math>c = 81</math>.</i></p>	TIP
<p>The teacher then said to the students, <i>These are the types of questions you will get in WAEC or NECO examinations.</i> The students were given some questions to solve using the examples in the classroom.</p>	

<p>(3) Find <math>b</math>, if <math>x^2 + 24x + b = 0</math>  (4) Find <math>c</math>, if <math>2x^2 + x + c = 0</math></p>	<b>TAP</b>
<p>The students learnt the concepts of square, perfect square and how to factorise quadratic equations by method of completing the square. The teacher used the traditional method and questions directly from a general mathematics revision textbook. He also used white board illustrations because there were no instructional materials and allowed the students to give chorus answers to his questions. He sometimes talked to the board instead of facing the students in his explanation. The teacher made emphasis on the WAEC high-stakes examinations to the students. The objective of the lesson was partially achieved.</p>	<b>TR</b>
<p><b>Teacher H</b>  The lesson planned was on simple and compound interest. The teacher used lecture method in his instructional approach. The lesson was a continuation of the previous lesson. The teacher revised the work on simple interest taught in the previous lesson. He then emphasized:  <i>During WAEC or NECO examinations don't forget to write down the formula before substituting the values and simplify to get the final answer.</i>  He then, continued with the teaching of compound interest. He said,  <i>Remember that simple interest is calculated at the end of period of savings. But for compound interest, the interest is calculated annually, and the interest is added to the principal to earn interest for the follow year. Compound interest is calculated cumulatively to the end of the period of savings.</i>  The teacher used two WAEC past questions as examples and gave the students some questions to solve in class.</p>	<b>TIP</b>
<p>Johnson pays <del>R</del>40 000 per year to save for his retirement. He pays this amount at the end of each year for 30 years at 12%. Using the annuity formula, how much will he earn at the end of the 30th year?</p>	<b>TAP</b>
<p>Teacher H went to the class with a piece paper containing written past question on high-stakes examinations. His instructional and assessment practices focused on revision for high-stakes examinations. However, he probed and connected students' understandings. The used traditional method and students' response to answers in choruses. He also applied examination restricted instruction. The objective of the lesson was partially achieved.</p>	<b>TR</b>
<p><b>Teacher I</b>  Indices and logarithms was the topic of the day. The teacher used the lecture method, a lesson notes book and textbook during instruction. The teacher solved</p>	

<p>the questions on the assignment given to the students in the previous lesson for the students to take correction. He then, explained how indices and logarithms are related. He explained that</p> <p><i>If <math>a^x = y</math> is the exponential form, then <math>\log_a y = x</math> is the logarithmic form. Provided <math>a &gt; 0</math>; <math>a \neq 1</math>; <math>x &gt; 0</math>; <math>x</math> and <math>y \in \mathbb{R}</math>. For example, index equation <math>2^3 = 8</math> as an equivalent logarithm equation, <math>\log_2 8 = 3</math>. The students were confused when the exponential form is written in logarithmic form because the logarithm is not in base 10. He further revised the laws of indices and logarithms <math>2^5 \times 2^3 = 2^{5+3} = 2^8</math>, <math>2^5 \div 2^3 = 2^{5-3} = 2^2</math> and <math>((2^4)^2) = 2^{4 \times 2} = 2^8</math> while <math>\log_2 5 + \log_2 3 = \log_2 5 \times 3 = \log_2 15</math>, <math>\log_2 16 \div \log_2 4 = \log_2 \frac{16}{4} = 2 \log_2 2</math>, <math>\log_2 8 = \log_2 2^3 = 3 \log_2 2 = 3 \times 1 = 3</math>.</i></p> <p>After these explanations, the teacher then, called on one of the girls in class to solve one the problems on the board, and later gave some class work. He was then going round marking and correcting students' work.</p>	<b>TIP</b>
<div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: fit-content;"> <p>Solve <math>\log_5 625</math> .</p> <p><math>\log_5 625 = \log_5 5^4 = 4 \log_5 5 = 4 \times 1 = 4</math></p> </div>	<b>TAP</b>
<p>Teacher I used the traditional method, blackboard illustrations and textbook. He assessed and connected the students' understandings of indices and logarithms. He articulated what mathematical ideas and/or procedures that students were expected to learn. The objective of the lesson was achieved.</p>	<b>TR</b>
<p><b>Teacher J</b></p> <p>The lesson of the day was on simple and compound interest. He explained the concepts of simple interest and compound interest and solved some examples. He said,</p> <p><i>Simple interest is the amount gained for saving money at a particular rate and at period of time. Formula for simple interest is, <math>I = \frac{PxTxR}{100}</math> where <math>I</math> is interest, <math>P</math> is principal, <math>T</math> is period of savings and <math>R</math> % is rate per annum. In compound interest, the interest of the first year is added to the principal, so is the second year cumulatively to the end of the period of savings. Our banks use compound in interest in calculating their customers' interest. The formula for calculating compound interest is, <math>A = P \left(1 + \frac{r}{100}\right)^n</math>, where <math>A</math> is the amount, <math>P</math> is the principal, <math>n</math> is the years invested and <math>r</math> % is rate per annum.</i></p>	<b>TIP</b>



<p>(3) y varies directly as x, if <math>x = 24</math> and <math>y = 12</math>, what is the relationship between x and y? When <math>x = 72</math>, what is y?</p> <p>(4) y varies directly as x and inversely as z. if <math>x = 25</math>, <math>z = 10</math>, what is the law connecting x, y and z? When <math>y = 28</math> and <math>z = 14</math>. When <math>y = 36</math> and <math>z = 64</math>, find x.</p>	<b>TAP</b>
<p>Teacher A used traditional method, questioning techniques and lesson notes during instruction. There were no instructional materials. However, he focused on understanding important and relevant mathematical concepts, processes, and relationships, create an environment that helped students made sense of the concepts that they were learning and encourage the students to think beyond the immediate problem and make connections to other related mathematical concepts. The student lacked knowledge of change of subject of equations. The objective of the lesson was achieved.</p>	<b>TR</b>
<p><b>Second visit: Teacher B</b></p> <p>The lesson of the day was on logarithms of numbers less than zero. The teacher explained the methods of multiplication, division, powers and roots of logarithm with digits less than zero with examples. The students had difficulty with the subtraction of negative numbers. He made emphasis with example,</p> <p><i>This is how you should treat subtraction of negative numbers with bars, for example, <math>(\bar{3}. 2) - (\bar{8}. 6) = (\bar{4}+1.2) - (\bar{8} +0.6) = (-4) - (-8) - (1.2) = (-4 + 8) - (1.2 - 0.6) = 4 + 0.6 = 4.6</math>.</i> The teacher gave the students some exercises and he was moving round in the class marking and correcting their work. At a point when he saw some the students' mistakes, he said <i>"I will not be in the examination hall to tell how to solve these question, remember you will be on your own.</i></p> <p>At the end of the lesson the teacher gave the students assignment to do during their prep time in the evening</p>	<b>TIP</b>

<p>Simplify using the mathematical table</p> $\frac{(0.3245)^2 \times \sqrt{2.8672}}{14.3569}$ <table border="1"> <thead> <tr> <th>Number</th> <th>Logarithm</th> <th></th> </tr> </thead> <tbody> <tr> <td><math>(0.3245)^2</math></td> <td><math>\bar{1}.5112 \times 2</math></td> <td><math>\bar{1}.0224</math></td> </tr> <tr> <td><math>\sqrt{2.8672}</math></td> <td><math>0.4575 \div 2</math></td> <td>0.2288</td> </tr> <tr> <td></td> <td></td> <td><math>\bar{1}.2512</math></td> </tr> <tr> <td>14.3569</td> <td>1.1571</td> <td>1.1571</td> </tr> <tr> <td>0.0124</td> <td></td> <td><math>\bar{2}.0941</math></td> </tr> </tbody> </table>	Number	Logarithm		$(0.3245)^2$	$\bar{1}.5112 \times 2$	$\bar{1}.0224$	$\sqrt{2.8672}$	$0.4575 \div 2$	0.2288			$\bar{1}.2512$	14.3569	1.1571	1.1571	0.0124		$\bar{2}.0941$	TAP
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<p>Teacher B used traditional method, questioning techniques, blackboard illustrations, textbook and four figure tables. He created an environment that helped students to make sense of the concepts that they were expected to learn. The lesson time was really devoted to effective teaching and meaningful learning of mathematics. The objective of the lesson was achieved.</p>	TR																		
<p><b>Cycle 2 lesson observation: Teacher C</b></p> <p>The lesson of the day was on revision practice. Teacher C picked WAEC and NECO past questions from his file based on the topics covered during the term.</p>		TIP																	
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<p><b>Cycle 2 lesson observation: Teacher D</b></p>																			

<p>The lesson of the day was on depreciation. The teacher explained with examples the concept of depreciation as an item that lose value over a given period of time. He defined,</p> <p><i>Depreciation is the reduction in an asset's value or commodity value over time due to usage or abuse, wear and tear. Depreciation is calculated using the rate at which the commodity reduce in value multiply by the purchased price, which is, depreciating percentage time the cost price.</i></p> <p>The teacher solved two examples and gave the students some questions to solve in the class.</p>	<p><b>TIP</b></p>
<div style="border: 1px solid black; padding: 5px;"> <p>3. A man bought a Toyota carina at ₦1, 500, 000 and sold it after 4 years at ₦900, 000. What is the rate at which the car depreciated?</p> <p>4. A television was purchase at ₦25, 000, it depreciated by 20% annually. What was price of the television after 3 years?</p> </div>	<p><b>TAP</b></p>
<p>In his instructional and assessment practices Teacher D focused on the students understanding important and relevant mathematical concepts, processes, and relationships, created an environment that helped students make sense of the concepts that they were expected to learn, and majority of the students were engaged in the lesson and they remain on tasks. The teacher used traditional method, questioning, blackboard illustrations with real-life situations and different textbooks were used for the lesson. The objective of the lesson was achieved.</p>	<p><b>TAP</b></p>
<p><b>Cycle 2 lesson observation: Teacher E</b></p>	
<p>The lesson of the day was on measures of central tendency (mean, median and mode). The teacher marked the assignment given to the students in the previous lesson and solved the problems on the board for the students to do corrections. The teacher wrote down WAEC, May/June 2017, question 10 and said,</p>	<p><b>TAS</b></p>
<p><i>Assuming a similar question is given to you during the next WASSCE, how will you solve it?</i></p>	<p><b>TAP</b></p>
<p>No body answered. Then the teacher said,</p>	
<p style="padding-left: 40px;"><i>Can we solve it together?</i></p>	<p><b>SAP</b></p>
<p>The students answered in chorus,</p>	
<p style="padding-left: 40px;"><i>Yes sir.</i></p>	<p><b>TAP</b></p>
<p>The teacher solved the question together with the students but allowed them to complete the final part of the question. He wrote 2016 May/June WASSCE, question 9 for the students to copy and practice.</p>	

The frequency table below present the marks of students in a statistics examination:

Marks	15-24	25-34	35-54	55-64	64 and above
Frequency	15	20	30	15	20

Marks	Frequency (f)	Class mark (x)	Fx
15-24	15	19.5	292.5
25-34	20	29.5	590
35-54	30	39.5	1185
55-64	15	59.5	892,5
65-100	20	69.5	1390
	$\Sigma f = 100$		$\Sigma fx = 5740$

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f} = \frac{5740}{100} = 57.4 \text{ marks}$$

In his examination time restricted revision, and instructional and assessment practices Teacher E focused on understanding important and relevant mathematical concepts, processes, and relationships and time was devoted to activities that emphasized on high-stakes assessments and revision. He used traditional methods, blackboard illustrations, textbooks and WAEC/NECO past questions papers. There were no students' interactions, they were only engaged in copying the solved questions in their exercise books. The objective of the lesson was partially achieved.

### **Cycle 2 lesson observation: Teacher F**

The lesson of the day was on profit and loss. The teacher used lecture and questioning techniques, textbook-bound student-centred in his instructional and assessment practices. He explained the meaning of the two concepts with examples. He said,

*Profit is the amount of money gained in buying and selling of goods or commodities and when those goods or commodities are sold at prices less than the cost price it is a loss. In business you either expect profit or loss.*

The teacher explained with examples on how to find profit or loss and their percentages. At the end of the lesson the students were given a take home assignment.

**TR**

**TIP**

A television set was marked for sale at GHc760.00 in order to make a profit of 20%. The television set was actually sold at a discount of 5%. Calculate, correct to 2 significant figures, the actual percentage profit.

TAP

Teacher F used traditional methods and blackboard illustrations and textbooks. The teacher aroused the students' interest in the lesson and they were asking questions. He then probed and connected the students understanding of the concepts by answering their questions and kept them on tasks by asking them to solve some problems in the class. During the lesson the teacher focused on instructional procedure and meaning (i.e. he was using procedure and explaining the procedure). The objective of the lesson was achieved.

TR

### Cycle 2 lesson observation: Teacher G

The topic of the day was evaluation of logarithms. Teacher G started the lesson by giving the definition of "logarithm", "antilogarithm", explained with examples. He said,

*"Logarithm of a number is the exponent or power to another fixed value, the base, must be raised to produce that number. For example, the logarithm of 1 000 to base 10 is 3, because 10 to the power 3 is 1 000:  $1\ 000 = 10 \times 10 \times 10 = 10^3$ . That is,  $\log_{10} 10^3 = 3 \log_{10} 10 = 3 \times 1 = 3$  (log of the base is one). Now the antilogarithm is the number of which a given number is the logarithm. For example, the antilogarithm of 3, if the base was 10 is 1 000".*

TIP

He said,

*Now, let me give you a WAEC question as an example.*

He wrote on the board,

*Evaluate  $\frac{82.47 \times 24.85}{299.3}$  "evaluate means to determine the number value of something or find the answer. Now get out your logarithms table and let us work this together.*

All the students except one had a four-figure tables, but he managed to solve the question given. After solving the examples, he then gave the students three questions to solve and walked out of the class.

TIP

The teacher gave more emphasis on WAEC high-stakes examinations in his lesson and his work with the students was an outline procedure of WAEC, WASSCE marking scheme. He taught logarithms of numbers greater and less than zero within one lesson because he was working with



<p>The teacher's lesson was over and had to allow another to enter for the next lesson. He was to continue with the topic the next lesson.</p> <p>Teacher H used traditional method, blackboard illustrations, a textbook and past questions papers. He focused on understanding important and relevant mathematical concepts, processes, and relationships, encouraged the students to think beyond the immediate problem and make connections to other related mathematical concepts and assessed and connected students' understandings. But promised to continue with the topic the next lesson using variety of past question papers on high-stakes examinations. The objective of the lesson was partially achieved.</p>	TR
<p><b>Cycle 2 lesson observation: Teacher I</b></p> <p>The topic for the day lesson was application of linear and quadratic equations. The teacher explained the difference between linear and quadratic equations with examples.</p> <p><i>A linear equation is an equation which highest power of the variable as one, for example, <math>ax + b = 0</math>. While a quadratic equation is polynomial in which two is the highest power of the variable, for example, <math>ax^2 + bx + c = 0</math>. In application of linear equations, we transform word problems into linear equations that may be solved algebraically. Likewise, in application of quadratic equations we transform word problems into quadratic equations that may be solved algebraically. Let us concentrate on quadratic equations because that is where WAEC mostly asked their questions in the WASSCE. To solve quadratic equations one can use factorization, completing the squares, quadratic equation formula or the graphical method.</i></p> <p>He further added,</p> <p><i>For this lesson we are using the graphical method.</i></p> <p>After working some examples using graphical methods he gave them one question from the WASSCE to solve in the class but none of them was able finished during the period of the lesson. They were asked to complete the work at home and bring it for marking the following day.</p>	TIP  SAP
<p>Teacher I used traditional method, blackboard illustrations, a textbook, WAEC past questions papers and blackboard mathematical instruments. He probed and connected the students' understandings. He managed to draw the graph using the plain blackboard because there was no graph board in the school. But the students had their mathematical instruments. The objective of the lesson was achieved.</p> <p><b>Cycle 2 lesson observation: Teacher J</b></p> <p>The lesson of the day was laws of indices. The explained meaning of indices with examples and list the laws of indices with examples. He explains,</p>	TR



the take-home assignment for the students to take correction. The teacher then continued with the lesson of the day. He then explained the concept of joint variation with examples.

He said,

*In joint variation, a variable varies directly and/or inversely to each variable one at a time. That is,  $x \propto ab \Rightarrow x = kab$  or  $x \propto \frac{y}{z} \Rightarrow x = k\frac{y}{z}$ , where  $k$  is a constant.*

After solving some examples, the teacher gave the students two WAEC and NECO past question papers from his lesson notes on the topic taught to solve in the class, but they were unable to complete solving them. The students were asked complete the classwork at home and bring it for marking the next day

The cost  $c$  of producing  $n$  bricks is the sum of a fixed amount,  $h$ , and a variable amount  $y$ , where  $y$  varies directly as  $n$ . If it cost GH¢950.00 to produce 600 and GH¢1,030.00 to produce 1000 bricks,

- (i) Find the relationship between  $c$ ,  $h$  and  $n$ ;
  - (ii) Calculate the cost of producing 500 bricks.
- WAEC 2015, question 5(b)

Teacher A used traditional method, and revision practice towards WASSCE high-stakes examinations. Instructional materials were not used. But he focused on teaching procedure and meaning and tasks stimulate complex, non-algorithmic thinking and revision practice towards WASSCE high-stakes examinations. The objective of the lesson was achieved.

### **Cycle 3 lesson observation: Teacher B**

The lesson of the day was on surds. The teacher returned the exercise books to the students after marking the assignment he gave them in the previous lesson and solved the questions so that the students that made

TIP

TAP

TR

<p>mistakes will take corrections. After which the teacher continued with the lesson of the day. He defined and explained,</p> <p><i>Surds are irrational numbers that are in root form which cannot be determined exactly, such as <math>\sqrt{2}, \sqrt{3}, \sqrt{5}, \sqrt{7}, \sqrt[4]{8}</math>, etc.</i></p> <p>He further explained the surd laws and simplification of surds to the lowest terms with examples. The teacher gave them class activity and later added some take home assignment.</p>	TIP
<div style="border: 1px solid black; padding: 10px; width: fit-content; margin: 10px auto;"> <p>Simplify to the follow to the lowest terms:</p> <p>(2) <math>\sqrt{72} \times \sqrt{32}</math> (2) <math>\sqrt{108} \times \sqrt{147}</math> (3) <math>\sqrt{64} \times \sqrt{148}</math></p> </div>	TAP
<p>Teacher B used traditional method and blackboard illustrations and textbook. He focused on procedure and algorithmic thinking, students were passive listeners but majority of them were engaged in the lesson and remained on tasks. The objective of the lesson was achieved.</p>	TR
<p><b>Cycle 3 lesson observation: Teacher C</b></p>	
<p>Teacher C selected some WAEC past questions papers from his file and then said,</p> <p><i>You know you are starting your examination next and you are expected to answer questions that are of WASSCE standard. So, we are going to revise some of the past questions in this lesson.</i></p>	
<p>After solving questions with the students for 30 minutes, then told the students,</p> <p><i>This where we are going to stop for today. If you have some past questions, you can practice them at home.</i></p>	TIP
<p>Then, he left the classroom.</p> <p>The lesson of the day was on revision. Teacher C continued with the revision of WAEC past questions from his file based on the topics covered against the end of term examination. He used the traditional method and blackboard illustrations. The students were passive listeners and were fully engaged in copying the solved questions done by the teacher from the blackboard. He</p>	TIP

achieved the objective of the lesson. The objective of the lesson was partially achieved.

**TR**

**Cycle 3 lesson observation: Teacher D**

The lesson of the day was on trigonometrical ratios. The teacher explained the trigonometrical ratios with examples that,

*For the trigonometrical ratios:  $\sin \theta = \frac{y}{r}$ ,  $\cos \theta = \frac{x}{r}$ ,  $\tan \theta = \frac{y}{x}$ , determines the values of the x- and y-coordinates and that the value of r is always positive.*

The teacher solved some examples on method of finding numerical values of trigonometrical functions (e.g.  $\sin(180^\circ + \theta) = ?$ ) on the blackboard using four figure table and gave the students some questions to solve using the four figure tables. And warn,

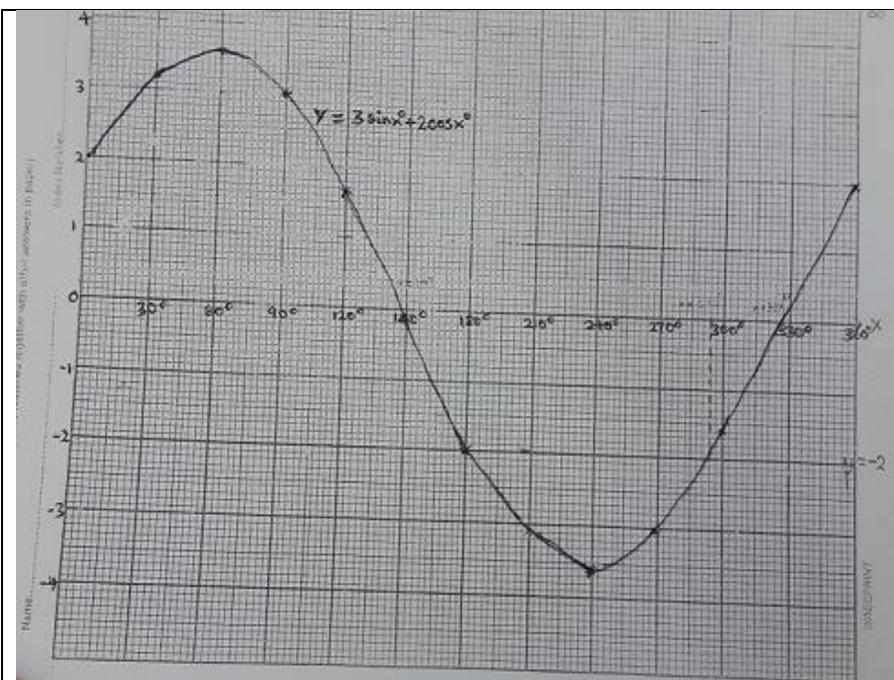
*Nobody should use a calculator of any kind because you will not be allowed to use it in the examination hall, except the scientific calculator provided by WAEC.*

**TIP**

$$y = 3\sin x + 2\cos x \text{ for } 0^\circ \leq x \leq 360^\circ$$

X	0 <sup>0</sup>	30 <sup>0</sup>	60 <sup>0</sup>	90 <sup>0</sup>	120 <sup>0</sup>	150 <sup>0</sup>	180 <sup>0</sup>	210 <sup>0</sup>	240 <sup>0</sup>	270 <sup>0</sup>	300 <sup>0</sup>	330 <sup>0</sup>	360 <sup>0</sup>
y	2.1	3.2	3.6	3.0	1.6	-0.2	-2,0	-3.2	-3.6	-3.0	-1.6	0.2	2.0

**TIP**



Teacher D used traditional method, blackboard illustrations, textbook, mathematical tables and calculator during the lesson. He focused on teaching procedure and meaning, understanding important and relevant mathematical concepts, processes, and relationships and majority of the students were engaged in the lesson and did they remain on tasks. Students were giving chorus answers to the teacher's questions. The objective of the lesson was achieved.

### **Cycle 3 lesson observation: Teacher E**

The lesson of the day was on solving quadratic equations using graphical method. The teacher explained that,

*In solving problems on quadratic equations we can use factorization, method of completing the squares, quadratic equation formula or the graphical method. I will use the graphical method because they always ask this type of questions in the external examinations and such questions demand more than just getting the factor or the roots of the equations.*

He further explained,

*To solve the equation  $ax^2 + bx + c + 0$  graphically, you plot the points on a table, transfer the coordinate points into the scaled graph, join the points*

and read off the values where the graph of  $ax^2 + bx + c + 0$  intersects the x-axis, because on the x-axis all the values of  $y = 0$ .

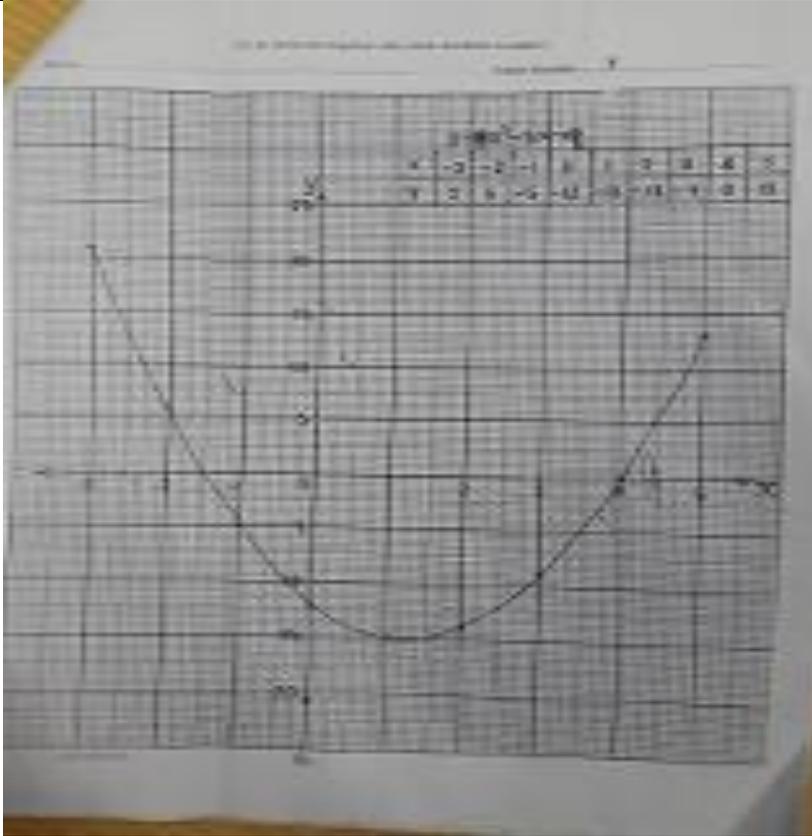
The teacher also explained some situations that may arise,  
 If the quadratic equation has two roots, the graph of the equation intersects the x-axis in two places. One root can be written as a perfect square  $(\dots)^2$ , the graph  $ax^2 + bx + c + 0$  intersects the x-axis in only one point or just touches the x-axis. No real roots, the graph of the equation does not intersect the x-axis at all. When you want to solve simultaneous equations such as  $mx + c = ax^2 + bx + c = 0$  graphically, you draw the graphs of the two equations  $y = mx + c$  and  $y = ax^2 + bx + c = 0$  and read off the x-coordinate(s) of the point(s) where they intersect.

The teacher then solved one question using the blackboard mathematical instruments. The students were asked to copy the table and draw the graph in their graph sheet. He gave the students assignments at the end of the lesson.

The table is for the relation  $y = px^2 - 5x + q$

X	-3	-2	-1	0	1	2	3	4	5
Y	21	6	-5	-12	-15	-14	-9	0	13

- (e) (i) Use the table to find the value of p and q.  
 (ii) Copy and complete the table.
- (f) Using the scale 2 cm to 1 unit on the x-axis 2 cm to 5 units on the y-axis, draw the graph of the for  $-3 \leq x \leq 5$ .
- (g) Use the graph to find:  
 (i) Y when  $x = 1.8$ ;  
 (ii) X when  $y = -8$ .  
 WAEC 2015, question 7(a, b, c).



Teacher E used the traditional method, textbook and mathematical instruments. He focused on teaching procedure and meaning, teach to students understanding of important and relevant mathematical concepts, processes, and relationships and majority of the students engaged in the lesson and they remained on task. The lesson time was really devoted to effective teaching and meaningful learning of mathematics.

### **Cycle 3 lesson observation: Teacher F**

The lesson of the day was on simple and compound interest. He introduced the lesson by explaining the difference between simple and compound interest. He explained:

*Simple interest is the money earned for saving or lending out money for a period of time and at a particular rate while in the compound interest the interest gain is cumulative. The simple and compound interest on a given principal at a given rate over a given period of time. We use simple interest formula,  $I = \frac{PxTxR}{100}$  to calculate the interest  $I$  if a principal  $P$  is invested for*

$T$  years at  $R$  % per annum. We use the compound interest formula,  $A = P \left(1 + \frac{r}{100}\right)^n$ , where  $A$  is the amount and  $P$  is the principal invested for  $n$  years at  $r$  % per annum.

The teacher solved some questions for the students as examples from the textbook he was using and from some WAEC past question papers.

3. A sum of ~~N~~4000 invested at a rate of 5%. What was the compound interest at the end 20 years?
4. Peter invested ~~N~~10000 for 6 years at 9%. What was his amount at the end, using compound interest?

In the classroom interaction, students were giving chorus answers to the teacher's questions. The teacher used traditional method, calculator, a textbook and some WAEC past question papers. The concepts and procedures in solving compound interest were understood by the students.

### **Cycle 3 lesson observation: Teacher G**

The lesson of the day was on statistics – bar charts and pie charts. After writing the topic on the board the teacher said

I want you to pay attention to this topic because it always appears in WAEC or NECO. *Bring out your mathematical instruments and your graph books so that we start in earnest.*

He defined and explains bar chart and pie chart:

*“A bar chart is a diagram with bars proportional to the quantities they represent and there are equal gaps in between bars while a pie chart is a circular diagram in which the sectors are proportional to the quantity they represent. In a pie chart, the angle of each sector is in the same ratio as the quantity the sector represents”.*

The teacher used data from some WAEC past questions and from the textbook he was using to work out the examples for the students. He drew the bar charts using a ruler and the pie charts using a ruler, a pair of

compasses and a protractor. The students were given assignment on the lesson taught.

Teacher G rushed to finish the topic because he was working with time to cover much from his scheme of work before the WASSCE high-stakes examinations begin in May, 2018. There was no graph board for drawing of the bar charts and the pie charts. Although, the teacher did not use a graph board he followed the construction step-by-step for students' understanding and the construction showed on the white board used.

**Cycle 3 lesson observation: Teacher H**

The lesson of the day was a continuation of investment and annuity. The teacher practiced WAEC and NECO past questions with the students and gave them some take-home assignment questions to practice. The methods applied by the teacher in the lesson were revision practice and examinations restricted instructions.

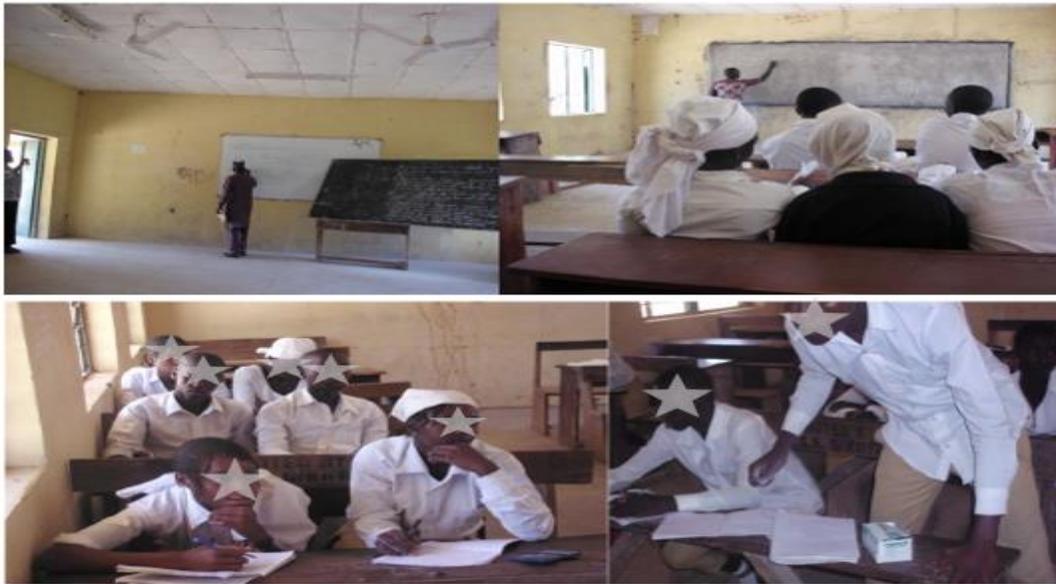
**Cycle 3 lesson observation: Teacher I**

The teacher continued with the topic of the previous lesson (linear and quadratic equations) he was unable to finish. He went round marking and correcting the students' work and later work the question on the board for the students to take correction. He then practiced more questions on quadratic equations.

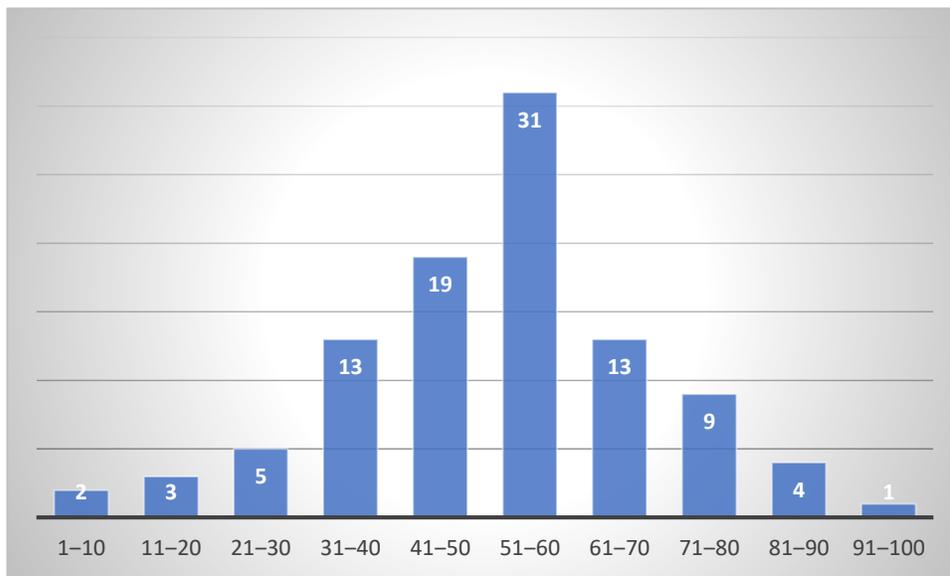
Students were allowed to discuss among themselves. Majority of the students were engaged in the lesson and remain on tasks. Students willing and openly discuss their thinking and reasoning. The tasks stimulate complex, non-algorithmic thinking.

**Cycle lesson observation: Teacher J**

The teacher continued with the students in teaching and learning of indices. He marked the students' work and solved the previous class work and the take-home assignment with the students.



Picture of teacher-students' interaction during instructional practices



The bar chart representing students marks in statistics examination.