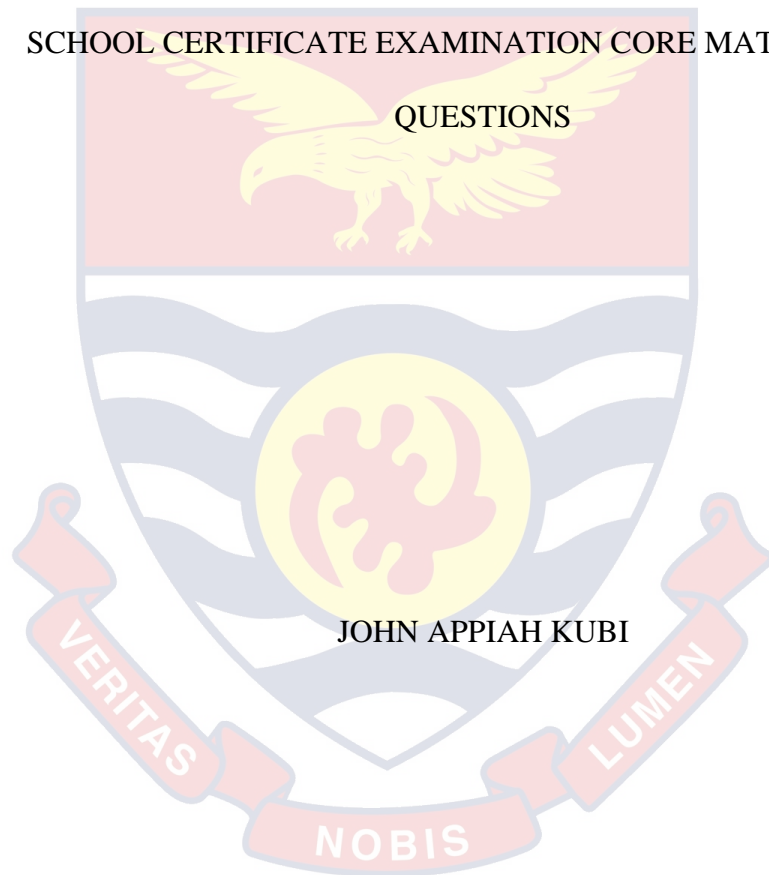UNIVERSITY OF CAPE COAST

ASSESSING CONTENT VALIDITY OF WEST AFRICAN SENIOR

SCHOOL CERTIFICATE EXAMINATION CORE MATHEMATICS

QUESTIONS

JOHN APPIAH KUBI

2021

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University of Cape Coast

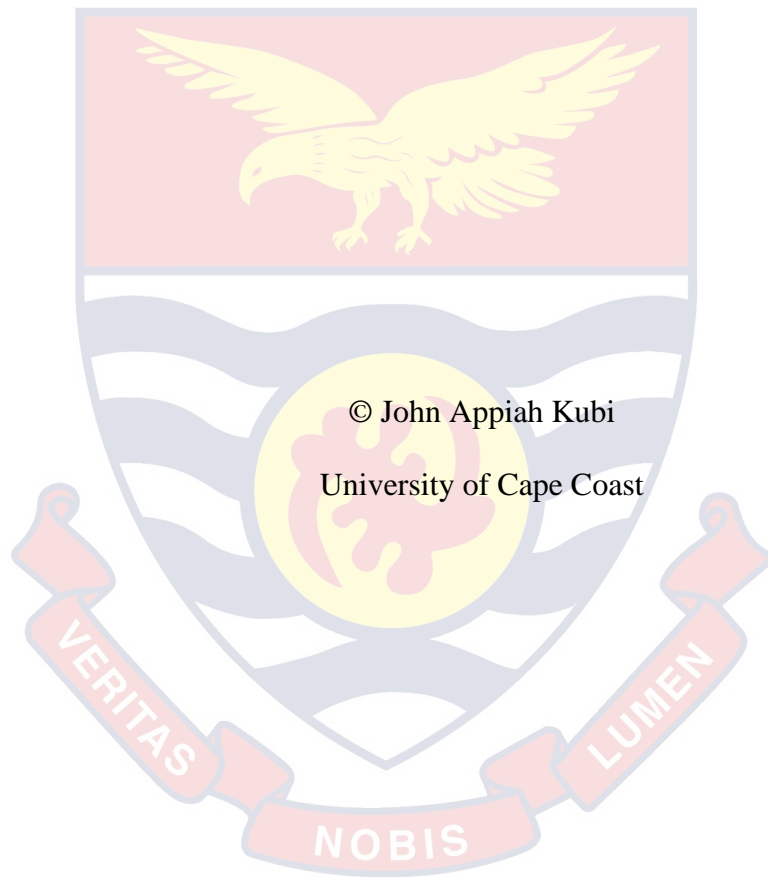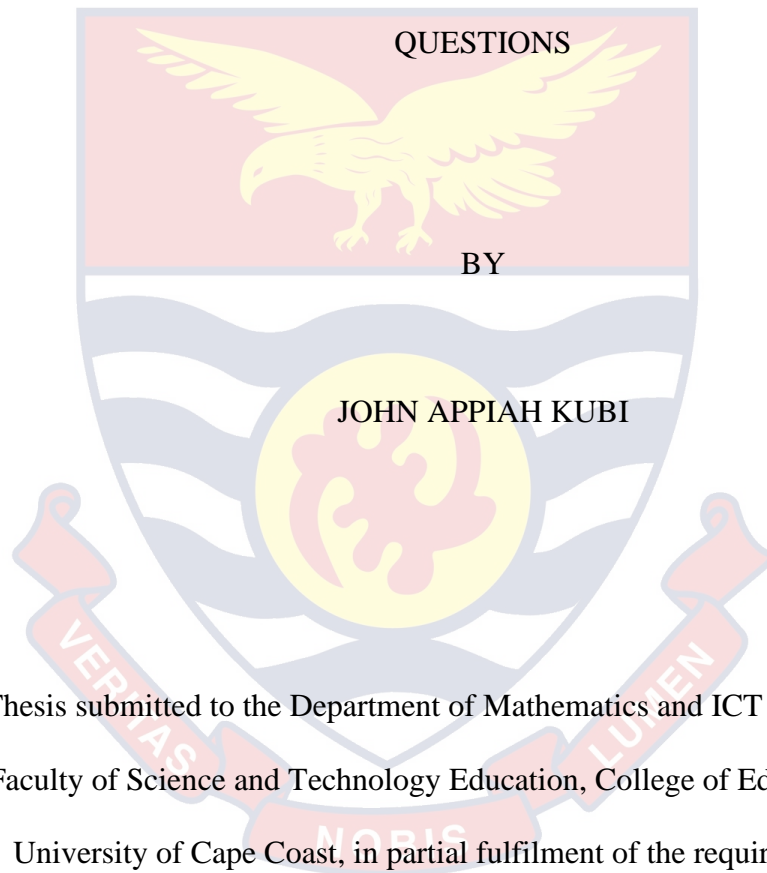UNIVERSITY OF CAPE COAST

ASSESSING CONTENT VALIDITY OF WEST AFRICAN SENIOR

SCHOOL CERTIFICATE EXAMINATION CORE MATHEMATICS

QUESTIONS

BY

JOHN APPIAH KUBI

Thesis submitted to the Department of Mathematics and ICT Education of the

Faculty of Science and Technology Education, College of Education Studies,

University of Cape Coast, in partial fulfilment of the requirements for the

award of Master of Philosophy degree in Mathematics Education.

MAY 2021

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the results of my own original research and that no part of it has been presented for another degree in this university or elsewhere.
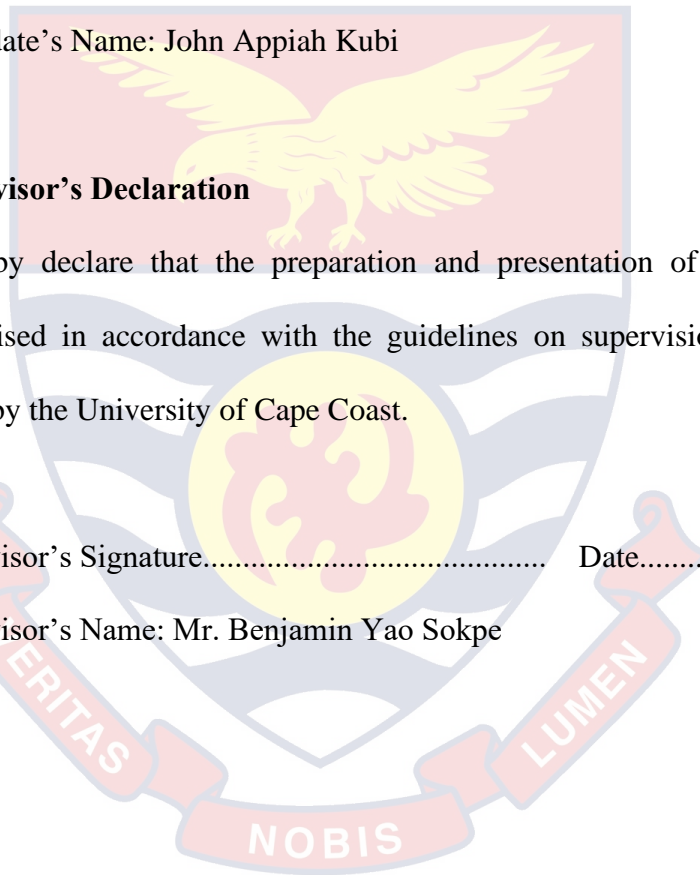
Candidate's Signature... Date.................................

Candidate's Name: John Appiah Kubi

Supervisor's Declaration

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

Supervisor's Signature.. Date................................

Supervisor's Name: Mr. Benjamin Yao Sokpe

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ABSTRACT

The study assessed the content validity of West African Senior School Certificate Examination core mathematics questions from 2009 to 2019. This document analysis type of research used Chief Examiner's Report, Ghana Education Service syllabus, West African Examinations Council syllabus and data sheets as instruments. Analysis of the taxonomic spread of the questions was done in respect of the contents of Ghana Education Service syllabus. Seven hundred and seven core mathematics questions were classified against the cognitive levels as stated in the core mathematics syllabus. The questions were the main source of data. The results showed that the West African Senior School Certificate Examination core mathematics questions has content validity issues and a higher percentage of the questions emphasised more of lower levels of the cognitive domain. Based on the findings, recommendations were made to policy makers, West African Examinations Council and other stakeholders to address the issue of content validity and how to ensure a balance between higher and lower order domains. Particularly, the West African Examinations Council must take cognisance in reference to fairness in the spread of items over the number of content objectives and inclusion of questions outside the teaching syllabus. The issues with content validity of the core mathematics papers have serious implications especially where important decisions are made in terms of the soundness and interpretations of students' results.

KEY WORDS

Chief Examiner

Content validity

Core mathematics

Ghana Education Service

Higher cognitive domain
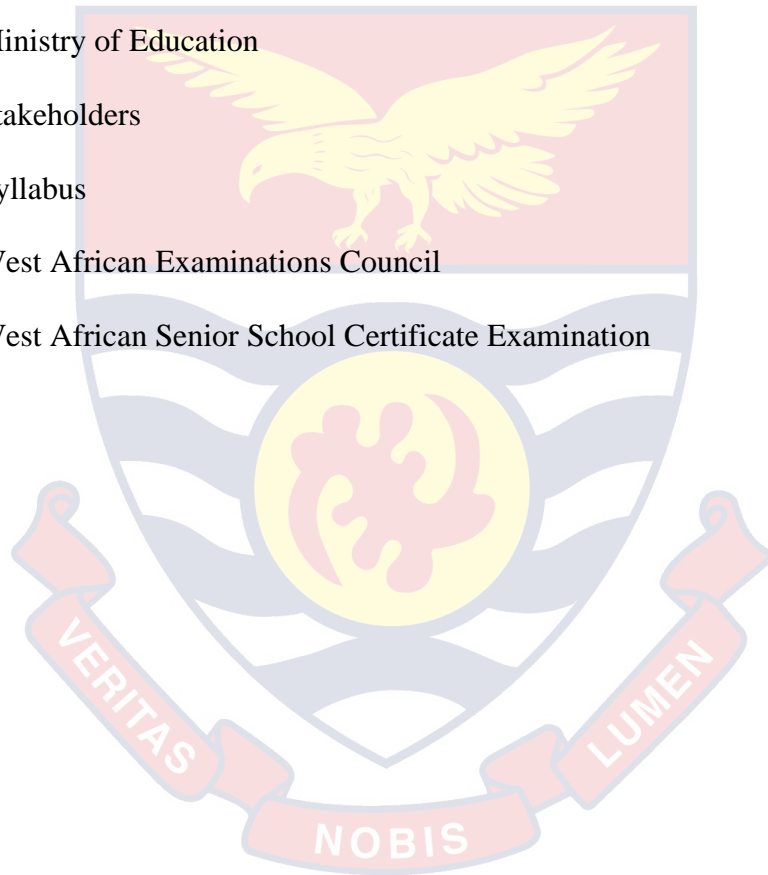
Lower cognitive domain

Ministry of Education

Stakeholders

Syllabus

West African Examinations Council

West African Senior School Certificate Examination

ACKNOWLEDGEMENTS

I am very elated to say thank you, Mr. Benjamin Y. Sokpe, my supervisor at the Department of Mathematics and ICT Education, whose efforts, goodwill and patience guided this work. Indeed, I am very grateful.

I am again grateful to my father, Mr. Kenneth Gyamfi Appiah for his unforgettable support in all spheres of my life. I will end with thanks to my family and friends for their support, especially my wife, Rita Appiah Kubi and my brother Raymond Bentil.

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DEDICATION

To my lovely children: Kayla and Israel

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LIST OF ACRONYMS

WASSCE	West African Senior School Certificate Examination
WAEC	West African Examinations Council
BECE	Basic Education Certificate Examination
JSCE	Junior School Certificate Examination
NECO	National Examination Council
HOCD	Higher Order Cognitive Domain
LOCD	Lower Order Cognitive Domain
GES	Ghana Education Service
MSLCE	Middle School Leaving Certificate Examination
EGSECE	Ethiopian General Secondary Education Certificate English Examination
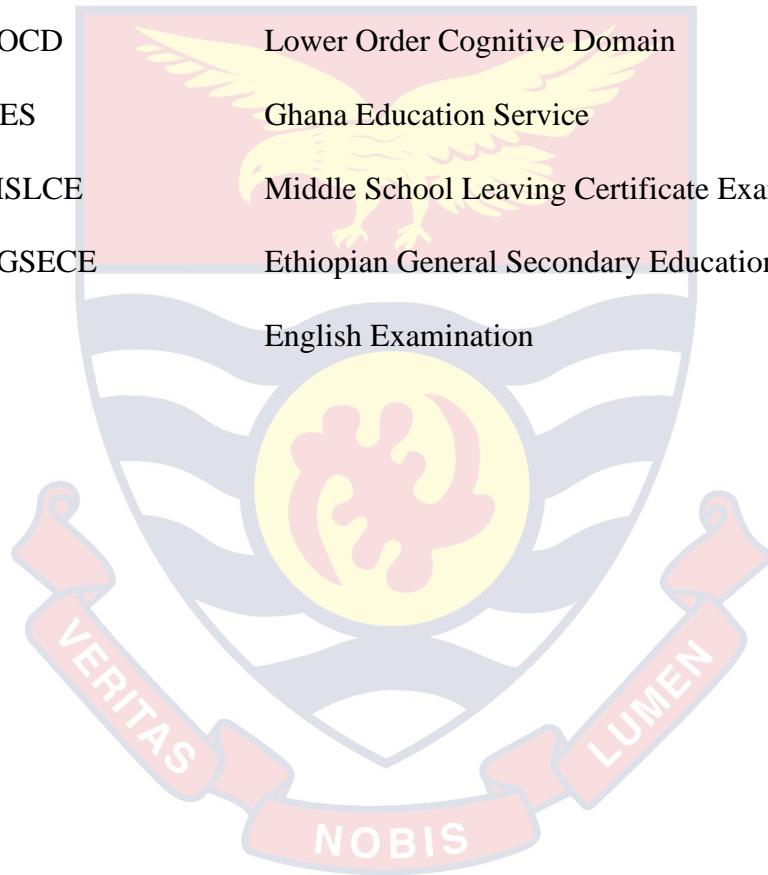
CHAPTER ONE

INTRODUCTION

Testing is one of the most widely used assessment tools in global educational settings of which West Africa and for that matter Ghana is not an exception. Standard practices in testing students are based on a specific syllabus content they have been exposed to. Anything short of this may reduce students' chances of excelling in the test. Due to perceived lapses in the way and manner West African Examinations Council (WAEC) conducts its examinations, especially the controversy that normally characterises the WASSCE core mathematics, many arguments have been raised and commentaries ran by stakeholders on the need for government to institute a parallel examining body for senior and junior high final year students. An article by Botor (2015) gained much prominence in the media space on the need for government to pave way for another examination body. This chapter provides a background of the study, a description of what the problem is, aim of the study, questions underpinning the research, how stakeholders stand to benefit from the study, how delimited and limited the study is as well as the meaning of some words used.

Background to the Study

Content validity which is the central idea of the study is explained as the adequacy with which test items represent sampled content areas of a syllabus, that students are to practise in their course of study. How well the content of the core mathematics syllabus is represented in the WASSCE core mathematics examination can impact on teaching-learning and testing processes. If a standardized achievement test is not rich in content validity or

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fails to measure what it purports to measure, it results in wash back effect on teaching and insufficient scientific interpretations of the test results. Students' life options and opportunities can be influenced directly by high-stakes examinations as suggested by Lester (2003); Moses and Nana (2007).

One of the assessment tools used in evaluating the academic performance of students is achievement test. It is therefore expected that the test items should be a true reflection of the topics and the cognitive levels enshrined in the core mathematics syllabus. Amajuoyi, Eme, and Udoh, (2013) reportage on content invalidity and low cognitive domain measurements of WASSCE chemistry questions shows how relevant and important this study is.

Records from WAEC show that Ghanaian students' performances over the years in WASSCE core mathematics have been poor. According to WAEC, within a period of one decade, the highest percentage pass at credit in core mathematics is 65.31% which occurred in 2019 WASSCE. Hitherto, more than 50% of students had failed every year since 2009. Ampadu, Butakor, and Cole (2017) mentioned that the performance of students both national and international has not been encouraging. There have been a lot of varying factors deemed to be negating the performance of students in these examinations. An earlier study by Eshun (2004) on classroom mathematics teaching and learning revealed that the way mathematics is taught in schools often creates fear, anxiety, and uneasiness for students. It also appears that most teachers teach students how to answer examination questions because students are not given the opportunity to learn a large proportion of the core mathematics curriculum.

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In 2018, the Ministry of Education, through its spokesperson, Vincent Asafuah, announced government's intention to investigate the poor performance of students in the WASSCE core mathematics. His assertions were that there is a lack of interest on the part of students or lack of commitment from teachers to help raise students' performance (Myjoyonline.com). A lot of concerns have consistently been raised within the public domain as to whether lack of teachers' commitment and students' disinterest in core mathematics are the only variables that need to be investigated.

A study by Amajuoyi *et al.* (2013) on WASSCE Chemistry questions reported that the questions lack content validity and most of the questions demanded lower cognitive performance of students to the neglect of the higher levels; application, analysis, synthesis, and evaluation. A similar study aimed at identifying and classifying the multiple-choice questions of SSCE chemistry paper 2A for 1997-1999 according to the cognitive process involved in the questions and comparing spread for each set of questions, reported item and sampling invalidity (Joseph, 2000).

Oye and Aborisade (2018) examined the item bias of mathematics examinations constructed by WAEC and NECO in Nigeria. The results showed that 88% of NECO items and 70% of WAEC items exhibited biasness. Pantzare's (2018) study on dimensions of validity of the Swedish national tests in mathematics, reported item validity and those interpretations made on the results of the national mathematics tests are valid.

Further studies by Yibrah (2017) on assessing the validity of EGSECE with regards its content also suggested problems of adequate sampling of test

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items. Elsewhere, Sibomana (2016) who studied the alignment between the Rwandan ordinary level national syllabus and national examinations for English reported that the contents of the national English examination and the national syllabus were aligned.

In the Ghanaian context, at the lower level, Awanta (2005) conducted a study to examine the link between the Basic Education Certificate Examination (BECE) and the mathematics syllabus standards in Ghana and reported that the BECE mathematics questions were aligned to the lower levels of cognitive domain and not evenly spread across the topics.

Studies by Moahi (2004) on how the Botswanaian Junior Certificate Mathematics Examination is valid in terms of content concluded that there was an inconsistent mathematics contents over the years which goes contrary to what the syllabus seeks to achieve.

From theaforementionedstudies and opinions, there is the need to explore whether the WASSCE core mathematics questions are content valid or not.

Statement of the Problem

One of the means of knowing how much grasps students have had in the course of teaching and learning is through testing. In order to pass an accurate judgement on students' performance, it is very necessary to look at what went into the processes of the test. Students' interest could die out if test items meant to elicit responses are poorly constructed. This view is shared by (Osadebe, 2001).

A test is deemed as valid and reliable if it measures what it is supposed to measure and does so in a consistent manner. Is that the priority of WAEC in

assessing students in the WASSCE Core Mathematics questions? How do the WAEC questions address the levels of cognitive domains as stipulated by the GES teaching syllabus for core mathematics? This study focused on the content validity of the WASSCE core mathematics questions as against the levels of cognitive domains and the topics in the core mathematics syllabus.

Purpose of the Study

The motive of the study revolves on finding out if WASSCE core mathematics questions by WAEC are a true reflection of the demands by the core mathematics syllabus for senior high schools in Ghana. The purpose of the study can be achieved by investigating whether the selected items in the WASSCE core mathematics papers were from the teaching syllabus in order to appropriately answer research questions one and two because that is the means the researcher could effectively assess the reflective nature of the WASSCE core mathematics questions vis-á-vis the teaching syllabus. The study focused on the WASSCE core mathematics questions, given that the scores generated are being used in critical decisions making. It was therefore very necessary and imperative for a proper scrutiny of test results and judgements passed on students' achievement in WASSCE core mathematics so as to establish the soundness of that interpretation. In furtherance to this, only content validity evidence is being collected for use in the validity argument in this study.

Research Questions

The goal of the study is to find out if enough justifications could be made in using the WASSCE core mathematics scores as one of the criteria for

purposes of selecting students into tertiary institutions. The research questions that guided the study are as follows:

1. What is the percentage of spread of the topics in the core mathematics syllabus as represented in the 2009 -2019 WASSCE core mathematics questions?

2. What are the percentage representations of higher and lower order cognitive domains in the 2009-2019 WASSCE core mathematics questions?

3. What is the relationship between the trend of students' performance and the cognitive domain levels in the 2009-2019 WASSCE core mathematics questions?

Significance of the Study

The study seeks to describe whether each test item of the core mathematics WASSCE questions represents the indicators as enshrined in the core mathematics syllabus. The findings of this study are expected to give a description to the readers about an analysis of content validity of the core mathematics WASSCE questions. Also, the study may add to the contemporary educational debate; whether or not it is necessary for another national examination to be established. This research is of important social value at this time in Ghana where WAEC has come under a lot of public scrutiny with regards to the performance of their duties.

Delimitation

The focus of the study is WASSCE core mathematics questions from 2009-2019.Questions which fell before the aforementioned period will not be accounted for. The study will be limited to content validity evidence; how

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representative the WASSCE core mathematics questions are, in respect of the GES core mathematics syllabus. However, the study will not take into account the item difficulty and item discrimination of the examination papers.

Limitations

Several aspects of validity evidence were not taken into account hence conclusive evidence on validity of the WASSCE core mathematics questions cannot be established. The services of test experts were employed in the classification of WASSCE core mathematics questions into the levels of cognitive domains and the topics in the core mathematics curriculum which may be subjective depending on how the person understands the import of the test items.

Definition of Terms

Outside questions: questions that came into the WASSCE from the WAEC syllabus but not from the teaching syllabus.

WAEC: regulatory body that conducts examinations for senior high school student finalists.

Organisation of the Study

The study comprises of chapters numbering one to five. It begins with chapter one which sets out the rest of the chapters. Chapter Twotalks about the theory the work is based on as well as a review of related studies. Chapter Three answers the question on how the work was done, the research methods, what design was used, the composition of the population, the approach used for sampling, instruments used for collecting data and how it was analysed. Chapter four presents the findings or results of the study.

Lastly, the fifth chapter summarises, conclude and make prescriptions of what stakeholders need to address.

CHAPTER TWO

LITERATURE REVIEW

The study aims at investigating past questions of WASSCE core mathematics in order to ascertain if the mode of assessments conforms to that which is prescribed in the GES core mathematics syllabus. It is by this that a sound judgement could be made on students' results. This chapter provides the theoretical framework on which the study hinges as well as how the current study relates to previous literature. The literature review comprises of related studies in the field of mathematics and other subjects at both basic and senior high schools in Ghanaian and non-Ghanaian contexts. Some elements this chapter talked about are the GES core mathematics syllabus, the WAEC syllabus, the Chief Examiner's Report, profile dimension, cognitive domain assessment.

Performances of senior high school final year students in the WASSCE Core mathematics examinations have been abysmal over the years as posited by (Musa & Dauda, 2014). According to statistics from West African Examinations Council (WAEC), it is almost certainly predictable that students' who participate in the WASSCE core mathematics examinations will fail to meet the minimum required grade. Since the WASSCE core mathematics examination is a high-stake test, this has generated and persistently creates fear and panic among major stakeholders especially heads of schools, parents, students and teachers. This is because core mathematics is a major criterion for selection of students to pursue higher academic degrees in the various tertiary institutions. There have been several arguments, speculations and discourse on the print, electronic and social media as to what

factors might have accounted for and are still contributing to this seemingly incurable canker. It is premised on this phenomenon that the researcher wishes to go into the current study.

One of the most important qualities of a test is how valid the test is in terms of its content. Test is a widely used assessment tool by teachers and other examination bodies as a means of determining the progress made by students after being exposed to a course as well as the effectiveness of a particular teaching approach. A test plays a key role when measuring students' competencies such as knowledge, skills, aptitude or fitness in a specified content domain. Joshua (2005) defined test as a logical method for assessing a sample of performance. It is very imperative that a teacher or a test constructor assesses the test items by asking this critical question; can sound judgement be made on the test?

Tests exist in the form of external or internal, standardized or non-standardized tests. The WASSCE core mathematics examinations being an external high stakes test are purposely designed for selection of students into various institutions to pursue further academic courses, placement purposes, counselling purposes and other scientifically based decisions.

Additionally, WAEC is also mandated for certification of students. WAEC makes use of the objective multiple-choice questions and the essay type tests in examining students. This enables the teacher or the examiner to include most of the topics taught. In view of this, one will not be far from the truth to say that this type of test to a large extent brings about attainment of content validity of a test. The essay type questions help to measure the cognitive attainment of the student. This is made possible because test takers

are allowed to express themselves without recourse to strict laid down procedures. The WASSCE core mathematics questions are supposed to be a syllabus-based achievement test.

Ghana Education Service Core Mathematics Syllabus

Education is seen as a means of transferring ideas, values and norms from persons to persons or generation to generations. Education is globally seen and accepted as the root of civilisation and the light to development. There have been several changes within the educational settings. An educational reform brings about changes or reorganisation of the structures in the educational settings with the aim of improving the delivery of quality education to the citizenry. In core mathematics, students who successfully get a mark that falls within the range of 60 to100, are awarded C6to A1 in WASSCE and can as well be admitted for further studies in institutions such as the polytechnics, now technical universities, educational and health colleges.

Another area that has generated some arguments as well as back and forth reforms had to do with how many years senior high school students spend in school in order to complete the national syllabus. In 2007, the government made senior high school students complete their cycle within four years and in 2010; there was a reform to reverse it to three years. Although, the reversing from the four years to three years in 2010 brought about some sort of reshaping of the contents of the GES core mathematics syllabus, it was done only by redistribution and or reorganisation of topics without the addition of new topics to the existing ones. Hence, same teaching syllabus has been used by teachers within the period under study. One repercussion that

ensued due to this inconsistent reform was that Ghanaian students were not able to sit for the WASSCE in 2010.

At the end of students learning in the senior high schools, they are made to take the Senior School Certificate Examination (SSCE). This was the situation before the inception of WASSCE in 2006.

Barring any unforeseen circumstances, the WASSCE is conducted in the months of April, May and June nationwide. Admission of students into the various tertiary institutions requires a minimum qualification of C6 in three of the four core subjects and any other three elective subjects. A student who fails to meet this requirement either tries their hope in the private examinations organised by WAEC known as NOV/DEC or give up the hope of ever getting into any tertiary institution.

The Ghana Education Service as an agency was established in 1974 by the National Redemption Council (Ministry of Education, 2017). It is primarily tasked to run the affairs of Basic, Senior High, Technical and vocational and Special Educations.

In order to establish a common policy for the development of education, there is a need for a strict adherence to a standard or a national syllabus for all stakeholders within the educational sector. Syllabus is defined as a set of learning experiences offered to students within a stipulated time frame under the guidance of the school. In the whole process of education, Syllabus has a vital part to play. For this to happen, a number of activities must be lined up and followed religiously by all players in the implementation of the syllabus. The core objective of the syllabus is to provide the individual with knowledge, abilities, attitudes, habits and appreciations.

The Ghanaian national core mathematics syllabus has topics which are arranged with some levels of familiarity and complexity. Teachers and students are supposed to complete the syllabus within the stipulated time of three years. Core mathematics is one of the major course's students must exhibit much competence in before being offered the opportunity to pursue further academic endeavours. In line with the importance of core mathematics to the academic life of students, much time is allotted to it in the senior high school for teachers to complete the syllabus successfully.

Interestingly, the GES core mathematics syllabus provides framework or mode of assessments for students. The syllabus spells out that any test, being internal or external, must measure up to the 30% and 70% lower and higher cognitive domains respectively in the profile dimension. In the spirit of the letter, the assessment mode of the syllabus seeks to contribute to the cognitive development of the students at that critical stage of their growth. The syllabus plays into the ever-changing needs of the society which is required of students to be able to handle higher order thinking tasks. In order to ascertain whether or not the intent or objectives of the syllabus are met, the WASSCE (core mathematics) is conducted by the government through the WAEC which is solely mandated by an ordinance.

From the description of the Ghana Education Service core mathematics syllabus, students are expected to be taken through 29 topics from first year to the third year. Moreover, students are supposed to have a firm grip of the topics in both theoretical and practical sense. It is therefore imperative that both internal and external assessors of these students take into cognisance the mode of students' assessments in terms of content representativeness of the

questions and the knowledge type the questions measure. Students must thus the assessed on the criteria of 30% and 70% for lower order cognitive domain and higher order cognitive domain respectively. Anything short of this will be an affront to the dictates of what the syllabus stipulates.

Once there is a general acceptance among the populace about governments' point of view on national examinations, then there is the need for the national examination to be seen as a benchmark to the extent to which a school has implemented the national syllabus in the right perspective. Therefore, the indicator of how successful or awful a school has implemented the national syllabus depends on the outcome of the national examination. For this reason, no impediment must halt the conduct of the WASSCE; no matter what is it or where it is coming from.

A statement by Tyler was cited by Arikunto (1992) that educational evaluation involves all the processes leading to the collection of data and basing on the data to find out how much of the educational objectives have been achieved. Currently, in our educational settings, there have been several discourses or debate about national examination. In general, there is a consensus among the populace that national examinations must not be used as a filter that determines who makes it to higher institution of learning and who are left behind. As an alternative, Appiah (2020), on peaceonline.com, suggested the adoption of an enhanced diagnostic and continuous assessment as a better way of awarding certificates.

Presently, grades are assigned to the subjects that students participated in when the results of national examinations are released through the official online page of WAEC. The results come with the no marks attached to

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subjects showing the performance of students in the various subjects, they have no idea as to why they performed well or otherwise, as well as the individual and total competence in all subject areas.

Profile Dimensions

One of the most critical ideas that is considered in the development of any syllabus over years has been the concept of profile dimensions. It is used to describe how much of behaviour a learner must be able to exhibit. More than one dimension constitutes a profile dimension. Each of the objectives in the GES core mathematics syllabus contains an "action verb" and an assigned 30% for Knowledge and comprehension whereas Applying Knowledge is assigned 70%. The percentage weight assigned to each dimension is a reflection on teaching, learning and testing of any sort within or outside the classroom. (GES core mathematics syllabus).

Knowledge and comprehension**:** Talk of one's capability to give meaning to what is learnt. One important feature that comes with has to do with being able to recollect facts, draw similarities and differences of what one has come across. (GES core mathematics syllabus). A student who operates at this level finds it difficult to interpret concepts learnt to new situations.

Applying Knowledge: deals with being able to transfer knowledge and ideas into new situations even if one is not familiar with it. Students who operate at this level see beyond just the meaning of the facts to how usable the facts are. One's ability to Apply Knowledge is categorized into four learning levels as explained below:

i. Applying knowledge is the ability of an individual to use acquired information in new situations. It involves high level of mastery of a

particular concept. It goes beyond just the memorisation of facts and figures.

ii.   Analysis also involves the process of analyzing knowledge. It makes use of recognizing the interconnectivity of parts of information.

iii.   Creativity has to do with one's ability to bring something new into being.

iv.   Evaluation is making a judgement of something. (GES core mathematics syllabus).

The West African Examinations Council

The WAEC was established in the year 1952 and is in principle a non-profiting organisation (WAEC, 2020). A bill to establish it was passed in 1951 comprising an initial four member states; Ghana, Nigeria, Sierra Leone and Gambia. Liberia became a part at a later date. The objectives of WAEC clearly indicate the sort of mandate given by member states. The WASSCE examination conducted serves a lot of purposes for both students and tertiary institutions. The various tertiary institutions rely on the results of the WASSCE for selection and placement of successful students. The first aim of WAEC is about conducting of examination in the interest of the public. The public includes parents, teachers and students whose interest is to see students assessed fairly based on the syllabus and successfully attaining the crown of victory.

Ultimately, the WAEC is committed to the certification of students but at a higher standard of attainment. For this reason, if the WASSCE questions fail to measure a higher standard of attainment, then the certificate ought not to be issued to students. WAEC therefore, needs to put in measures that ensure

validity of the questions. The WAEC has its own syllabus for core mathematics comprising same topics in the GES core mathematics syllabus except topics such as Matrices and determinants, Longitudes and latitudes, financial arithmetic and Calculus (Differentiation and Integration). Even though this syllabus exists, very few schools and teachers are even aware of its existence. A study conducted by Bosson-Amedenu (2018) reported on the impact of WAEC syllabus on the attainment of Ghanaian WASSCE candidates in terms of mathematics. He further concluded that private candidates who were taught with the WAEC syllabus performed better as compared to the counterparts taught with the GES syllabus. Also, majority of teachers who handle mathematics were not aware of the existence of the WAEC syllabus.

Studies have repeatedly revealed that high-stakes examinations tend to influence how teachers conduct instruction and assessment in the classroom. Steeves, Hodgson, and Peterson (2002) narrated the propensity for teachers to cover those topics they believe would certainly form part of the assessment. Such a practice which is known as teaching to test within the educational settings could have very daring repercussions on our society at large. Narrowing of the syllabus as a result of deliberate elimination of those parts of the syllabus that are not covered in the high- stakes tests is one of the negative effects of teaching to test.

Questions that remain on the lips of students and teachers include; "Is the WAEC syllabus the teaching syllabus?" Is it available for students and teachers?" If even made available for all schools and students, will it be

completed alongside the national syllabus? Is there a need for the WAEC syllabus? These and many other questions are begging for answers.

The Chief Examiner's Report

The report over the years seems to highlight some reoccurring impediments to students' output in the WASSCE core mathematics examination. Some strengths and weaknesses of students with reference to paper 2 of the examination over the years have been listed below. The report listed some strengths and weaknesses of students in the WASSCE core mathematics over the years with regards to paper 2.

Some of the strengths of candidates include most students were able to:

1. use Venn diagram to solve probability problems

2. solve the quadratic relations by completing the table values.

3. find values of a variable by using a given mean.

4. evaluate a binary operation when a set of numbers are defined.

5. express a vector in a column form through the use of a midpoint.

Some weaknesses of the candidates include most students were unable to:

1. find the values of a logarithm;

2. translate statements from word to mathematical symbols and solving them.

3. use completing the square method in solving a quadratic equation;

4. handle questions involving two matrices and as well as financial mathematics;

It is very necessary for stakeholders in the educational sector to critically look at the chief examiners report especially mathematics and take a keen interest in issues affecting the performance of students in the core mathematics

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examination. Issues of the strengths and weaknesses of students who sit for the WASSCE core mathematics examinations are thoroughly discussed. The report normally provides a clue of areas or topics within the syllabus where students find it problematic to handle. Specifically, the 2017, 2018, and 2019 chief examiner's reports highlighted four additional areas of students' weaknesses on; matrices and determinants, integration and differentiation and financial arithmetic and longitude and latitude.

Ironically, these topics are not found in the GES mathematics syllabus; the document teachers and students are supposed to use for teaching. Students' inability to handle word problems in mathematics goes to confirm the demand of a higher cognitive development. Such areas require that one operates at a higher level of cognitive domain which involves manipulation of the problem so as to find a solution. The WASSCE core mathematics questions would go a long way to help in students' cognitive development if the questions go in line with the profile dimension of the syllabus.

Theoretical Framework of Content Validity

Changes in conceptualization have brought about some debates in academic discourse on the issue of validity for the last ten years. Two scholars who have been front liners in advancing major changes that have further culminated into opinions which are responsible for the theoretical basis that determines validation studies are Angoff (1988); Sireci (1998b). Within the periods of 1930s through to 1950, Angoff made an observation that the principle of prediction influenced the concept of validity, and correlation was a method for assessing validity evidence.

The concept of validity is not a new one. Conceptualizations of validity are prevalent in literature from around the turn of the twentieth century, and since then, they have evolved significantly. Psychologists were rather focused on construction of predictors without recourse to the criterion (Jenkins 1946). In the analysis of these issues, other aspects of validity started to generate interest. Curreton's (1950) chapter on "Validity" in the first edition of Educational Measurement apart from reflecting on aspects of relevance and reliability also recognized the existence of content validity.

A new dimension of conceptualizing validity had been generated out of this chapter. Content validity is used to ascertain what it purports to measure. The validity of a test has to do with the representative nature of all the range of possible items the test is supposed to cover, in this case, the topics in the core mathematics syllabus must be adequately represented. It is therefore not far from the truth to say that the most fundamental consideration in developing and evaluating a test has to do with the content validity of the test. Aiken (2000) agrees that content validity must seek the representativeness of possible responses out of the entire proportions.

Many scholars have come out with different definitions of content validity. Even though, the wordings are different the meaning remains the same. Alderson, Claphan, and Wall (1995); Harrison (1983) explained the concept of content validity as how test items represent all contents of a particular domain (syllabus) in a proportional manner. It is explained by Bachman (1990) as how a test adequately samples the behavioural domain in question. Weir (1990) sees content validity as "degree that tests sample as

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extensive as possible the relevant, decisive and communicative items from the syllabus in order to have a beneficial wash back effect on teaching."

When content validity evidence is lacking of a high-stakes test, the repercussions are so daring. It thus becomes very necessary for regular content validity researches to afford both test developers and administers a much more defensible decision (Hambleton, 1984). Lennon (1956) concluded that there would be lack of confidence to sufficiently rely on a test result in situations where the test lacks validity.

Concepts Related to Content Validity

Some essential concepts encountered in validity assessment are: face validity, curricular validity and instructional validity. According to Crocker and Algina (1986), face validity is how far items on a test purport to assess the constructs that are significant to examinees. Thorndike (1997) shared the view that face validity becomes very crucial in order to get students' confidence in the test through fairness or to get examinee wishful collaboration. Furthermore, face validity was described by Angoff (1988) as appearance of validity and he observed that though the term came into existence as early as the 1940s, it has not got the much technical interest it ought to.

The term curricular validity has been used to illustrate how appropriate the test items represent the curricular objectives of an institution. Test and the objectives of the syllabus present a correspondence between them in the form of curricular evidence (Yallow & Popham, 1983). In the case where the achievement test is syllabus-based, curricular and content validities seem to have some sort of a relationship. More often than not, the objectives of the syllabus determine which content domain to select. Then again, test blueprints

are drawn from curricular objectives that describe the content. Content validity and curricular validity are two terms which cannot be used interchangeably simply because they have a common basis due to the fact that they explain different emphasis.

The significance of the test to the objectives of an institution's syllabus is what curricular validity is about. However, the same syllabus which is made up of and achieved through a number of objectives produce evidences of which both curricular and content validities are derived from, which is also the focus of achievement test. Hence, there is an overlap between content validity and curricular validity in terms of the domain they represent. It was argued by Messick (1989) that curricular relevance is curricular validity. Even so, it has been suggested by some scholars that instructional experience must be taken care of since the claims of test relevance alone are not enough.

Another argument arises paving the way for instructional validity, another term which generates some amount of confusion with content validity. Yallow and Popham (1983) make an interesting description of instructional validity as being "the correspondence between the test and instruction". It shows the preparedness of examinees through adequacy of instruction towards the test that assesses the domain on which the examinees were instructed. Due to its spotlight on how examinees are equipped for a test, Yallow and Popham made advancement in their argument that it should be called adequacy-of-preparation instead of instructional validity. For that matter, instructional validity refers to the justification on the usage of a test in preparing the examinees in the content being assessed. Moreover, Messick (1989) made an

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admission on the adequate representativeness of test items to the immediate objectives on which examinees were actually instructed in but dismissed the instructional relevance as another way of validity. High-stakes test developers must be constantly reminded to centre their assessment on the student and in order that instruction may be improved. If not, the judgements and or interpretations that are made on the premise of the results of such tests are without any justification.

Instructional relevance is thus making inferences about the domain of interest and has got nothing to do with the preparedness of examinees for a test. This is quite different from the meaning of content validity. It is an undeniable fact that major stakeholders such as policy makers do worry about examinee preparedness towards achievement tests; especially in high-stakes examinations as much as they worry about item-objective agreement due to the way results are interpreted. Ediger (2002) has suggested that for a test to be meaningful, it must be able to measure what students have had the chance to learn, as part of their instructional objectives that teachers used. However, the argument advanced by Yallow and Popham (1983) is that adequate preparation of examinees is not a necessity for prudent inferences to be made about what results connote. In other words, a test remains valid when it adequately covers the domain to be measured even if examinees are ill - prepared towards the test. Nonetheless, one will not be far from the truth to say that establishing content validity sets the premise for the scrutiny of adequate preparation, failure to ensure that will only add to the unconstructive effects of a test. With regards to the impact of testing, Cronbach (1988) in responding to the claims made by Yallow and Popham stated "You may wish

to exclude reflections on consequences from the meanings of the word, 'validation', but you cannot deny the obligation" (p. 6).

The emergence of a new term of "consequential validity", as a result of the concerns of test consequences has brought a lot of commitment on validators and has enjoined the old validity terminology debate. An advocacy was made by Messick (1989) on the need to include test validation process in view of its use and the results interpretation with respect to the importance of test consequences. A mention was made by him in reference to consequential validity as being latent, occasionally undesirable, and unexpected effects of an examination. For example, in Malawi the use of a single examination to select students for higher educational opportunities has led to rampant cheating in examinations (Chakwera, Khembo and Sireci, in press; Malunga, 2000).

Much weight has been put on apparent damages to individuals, schools and the educational system as a whole by critics of testing with respect to the negative impact of national examination which is high-stakes in nature. Teaching to test has been the order of the day in most schools as a result of high-stake tests, and has resulted in teachers relying on test to make instructional decisions. This is an observation shared by Steeves, Hodgson, & Peterson (2002). Thus, an argument is being advanced that besides narrowing the syllabus, teaching to the test has often times portray test as being an object of instruction instead of the result of previous instruction because much time is being spent on memorisation of facts than on hands-on curricular activities. Chakwera *et al.* (in press) reported with keen observation a comparable effect in respect of assessing Agriculture in Malawi where emphasis can no longer be laid on the practicality on the subject during instruction because the MSCE

examination in Agriculture no longer measures projects, as was formerly the situation.

Reportedly, an advocacy was done by Crocker (2002); Ryan (2002) for the involvement of stakeholders such as administrators, students, teachers, businessmen or potential employers on the needed information with regards to consequential validity of a high-stakes examination. A heartening result has been reported by Frye, Litwins, Ofoegbu, and Szauter (2002) on curricular validation study, in which a number of stakeholders were involved. In line with this understanding, a proposal was made by Geisinger and Sireci (1995) that test developers should make certain of content validity by way of sufficient definition and specification of content domain, making of test blueprints that sufficiently represent the content domain, and developing test items that encompass enough representation of the test blueprint.

A quality test can be obtained when it is developed meticulously and tangible inferences can be made about test takers with the scores generated in respect of the construct being measured. When there cannot be a description or establishment of congruence between test items and specification then interpretations of examinees' test performance are meaningless (Popham, 1984). It can be argued reasonably that when it comes to quality of a test, content validity should be the first point of call and a criterion that test developers must satisfy.

Even though, there is recognition of an interlocking relation between content validity and construct validity, it is very necessary to note that the two validity forms deserve separate validation. However, one would not be wrong to say that construct validity is deficient without proof of content validity. The

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key role of content validity is to ensure that the construct being measured is adequately represented. Hence, appropriate inferences about test results can be sufficiently articulated if and only if the instrument from which the results are obtained is valid. It has been disclosed by Sireci (1998b), that 'validity' as used in content validity means trustworthiness or the reliability of assessment tool itself for assessing the construct under study. Thus, a requirement for any score-based evaluations such as construct validity is ensuring content validity of the assessment tool.

There must be a full description of the domain of interest instead of being defined after test has been constructed. Content validity puts much weight not solely on the relevance of item content but examinees' response to the domain of interest. It could be inferred that if the test designers go by these suggested guidelines, then the likelihood is that relevant test items would be included in the test.

Categories of Content Validity

Again, a further significant development of the 1950s was the acknowledgment of all other forms of validity. This view is shared by (Sireci, 1998b). This brought about a significant step for the advancement of content validity because it was marked as the type of evidence that shows how well a test makes use of a specific domain area without necessarily displaying the worth of a test for any purpose. Sireci (1998b, p. 88) cited "The 1952 Technical Recommendation for Psychological Tests and Diagnostic Tests" by acknowledging the unique role and stated that content validity is normally verified in any academic achievement test.

There has been a remarkable deviation with the recognition of content validity from the dominance of statistical validation studies that used correlation of the predictor and the criterion as validity evidence. Predictive and concurrent validity were also brought about as types of validity in the same 1952 Technical Manual and these disclosed the need for statistical evidence (Angoff, 1988). An assessment of content validity would still be achieved by making judgement on the sampled in a domain of reference. Test validation in the light of this development began to concentrate on the quality of a test instead of its relationship with some other measure. The test constructor begun to receive a major attention in view of the fact that content validity was therefore seen as very significant for the achievement and in proficiency measures. Validity became a necessary feature that should be ensured as a test is being constructed. Much emphasis had to be placed on the use of table of test specifications prior to test construction as one way of ensuring content validity.

According to Sireci (1998b), there have been an emergency with a shift in favour of construct validity when a paper by Cronbach and Meehl (1955) was presented. Subsequently, the conceptualization of validity started to move towards the unitary concept and how validity was defined began to reflect this shift in thinking. This conceptualization of validity did not look at only exalting the position of construct validity but also brought new insight into the definition of content validity. For instance, content validity according to Lennon (1956) is how well the sample of responses of a test taker to the test items represented the supposed pool of cases of interest to the examiner giving meaning to the test scores. In line with this definition, responses instead of

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only items were prominent in the definition of content validity and hence content validation was to be the focus of the interaction between the test content and examinee responses.

According to Sireci (1998b), Lennon earned the reputation with the provision of a justification for the usage of content validity, which was subsequently backed by Ebel (1956) whose argument was that content validity provided a basis of construct validity. Sireci (1998b) accepted the fact that it was Loevinger (1957) who made a key shift toward a unitary concept as a result of construct validity framework being developed when the concept of substantive validity was to incorporate the concerns of content validity. An adoption was done into the Standards (APA, AERA, & NCME, 1966; 1974) with the shift towards the unified concept and in furtherance to this was elaborated by Cronbach (1971).

Sharply contrasting to this, Messick (1988; 1989) vehemently opined the removal of some aspects of validity such as content and criterion - related in favour of construct validity. At present, the most acceptable definition of validity refers to an assessment of the sufficiency and appropriateness with which meanings are attached to the uses of assessment results (Linn & Gronlund 2000; Messick, 1989).

Generally speaking, current definitions of validity place emphasis on score interpretation and its utilisation as the basis of validity assessment. This brings about a shift in attention from test validation on test and scores to interpretation of scores in the context of their use. According to Cronbach (1971), validation entails the steps taken in gathering of information which is accurate enough to make definite pronouncements. AERA (1999) came out

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with the steps involved in validation comprising of gathering information to serve as a basis for a sound scientific interpretation. Scholars are in congruence that all divergent opinions should be fully rationalize the interpretation of the results , even though the idea of a unitary concept in favour of construct validity has been pushed far enough. In this respect, before any justification of construct validity the issue of content validity must be established.

Role of Content Validity as a Test Quality

The indispensable nature and contribution of a test validation process gives credence to the relevance and representation of test items to the domain of content. When one examines the worth of a test with respect to what the test assesses and the purposes it serves, one cannot underestimate the contribution of test validation process. The evidence of content validity is useful when concerns such as construct, test purpose, or degree of domain representation are scrutinized. In line with achievement testing where scores symbolize mastery of the content being assessed, content validity with its emphasis on the congruence of items to content domain cannot be ignored.

Despite the usefulness of content validity as a form of validity, it was rejected by Messick (1988; 1989), who recognized the significance of evidence in relation to the adequacy of domain coverage and representativeness of items or tasks. This can be concluded that there exists no construct validity if content validity of a test is not established because test scores can be better interpreted depending on how well the test represents what it assesses. This view is also shared by Sireci (1998b) who stated "Obviously, we cannot, and should not, evaluate test scores without first

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verifying the quality and appropriateness of the tasks and stimuli from which the scores were derived" (p. 103). This gives more prominence to content validation as an important process in the sense that it is a sure way of checking on adequacy of construct representation. For that reason, whether content validity is designed to meet the wants of construct validity or on its own accord, both the test developer and user should endeavour to satisfy it, more to this when it is not just any type of test but achievement tests.

Significance of Content Validity in Achievement Tests

In the teaching and learning process, all forms of validity is very important, however, Hughes (1989) contended that in the achievement of each content objectives of a syllabus or pool of domain, for instance, content validity is the most significant tool to use. The necessary information is provided to major stakeholders on progress made by students in each aspect of the syllabus if the test is valid in terms of coverage. Then again, it is obvious that students would be more dedicated to learning each aspect of the course they offer if tests have adequate content validity. If not, students will ignore the studying of areas which are assessed less or not at all in an examination. It is only fair to say that much attention would be given to areas which are mostly assessed.

By and large, scholars are in agreement on both the existence and significance of content-related evidence in testing. Meanwhile, those who argue for the exclusion of content validity from the validity concept say so on the premise that its coverage on issues of score interpretation and use is insufficient, which they claim should be the focal point of test validation. From all indications, these opinions that item representations of the domain

under study, or item and domain agreement, cannot be overlooked in achievement testing. It is clear that unless the content validity of the test that produces scores is established it will not be justified to make inferences obtained from high-stakes test. It must thus be concluded that in fulfilling the purpose of testing, content validity remains a key quality to be looked at in testing, mainly when test scores are thought to be a representation of students' achievement.

It has been suggested by Walelign (2006) that test blueprint is a mechanism that has been extensively used with the aim of making a test valid by way of course content. It is normally called content validity chart. It is not feasible to practically test students on all contents taught. However, constructing a test with no plan will definitely lead to a washback effect. Test blueprint aids in building a balance test by embracing all contents taught in a proportionate manner. Lastly, it helps candidate to better organize their time as their confidence gets boosted especially with regards to test fairness.

The WASSCE core mathematics questions are purposely constructed to elicit responses from students pertaining to their achievement in core mathematics. The questions would then be valid if and only if they measure the achievements of students in the area of core mathematics based on the core mathematics syllabus. This assertion is influenced by Hathcoat (2013) who claims that judging the validity of a test is premised on whether or not the test measures what it intends to measure. Achievement tests which are high-stakes in nature result in interpretations that give forth categorization of students into those who passed or failed. Normally, those who passed are subsequently grouped into subcategories such as good, very good, credit, or distinction.

In the Ghanaian educational settings where some interest groups rank senior high schools on the basis of the results their students had in the WASSCE, teachers whose students do not live up to expectations are either queried to answer questions or transferred for non-performance. Heads of senior high schools that have been made to sign performance contract with the appointing authorities also receive their fair share of the blame by being held responsible for such a display of performance by their students. The community in which such schools are located do not take poor performance of students in the WASSCE lightly at all. This situation fits into Ryan's (2002) disposition that schools are held responsible to improve the quality in delivery of instruction, student learning, promotion of grade, and certification of students on the premise of high-stake tests.

Cognitive Domain Assessment

The current study made use of the work of Bloom. Formerly, it was a scheme use for the classification of educational goals in the evaluation of student's performance. There have been several revised forms of Bloom's is still relevant and utilized in today's education. Originally, the intention in the creation was to look at the cognitive, affective and psychomotor domains. The cognitive domain talks about "the recall or recognition of knowledge and the development of intellectual abilities and skills";

the affective domain is about the "changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment"; and the psychomotor domain encompasses "the manipulative or motor-skill area". It has been suggested by Craft (2005); Gallagher, Hipkins, and Zohar (2012); Shaheen (2010) that many issues and concerns have been expressed across the

length and breadth of many nations on how cognitive skills could be effectively integrated within their national curricula. Higher Order Cognitive domain (HOCD) is incorporated into many learning programmes as a result of educational reforms that have been implemented. This opinion is shared (Lin, 2011; Shaheen, 2010).

It is difficult for one to define HOTS or Higher Order Cognitive Skills (HOCS) but it is easily noticeable when one comes across it. A definition by Thomas and Thorne (2009) was that higher order thinking has to do with thinking at a superior level instead of just recalling facts or re-saying what one has heard from others. In higher order thinking, the individual has to do something about the fact, connecting it to facts in other ways to arrive at solutions to problems by way of familiarisation and making conclusions about the facts. Higher order thinking is generated when there is a continuous correlation of stored knowledge and prior knowledge in order to achieve a target. In other words, students who are able to exhibit much competence in higher cognitive level do so by connecting pre-existing knowledge with an encountered problem, in order to unravel it. In solving complex mathematical concepts, students at higher order thinking tend to apply logical reasoning instead of just a recall of prescribed procedures or methods. This can be achieved through the mastery of concepts. Experts have adopted different cognitive domains based on the Bloom's Taxonomy as shown in Table 1.

Table 1: HOCD based on Bloom's Taxonomy

Yen	Abosalem	Thompson	Fisher
Application	Application		
Analysis	Analysis	Analysis	Analysis
Synthesis	Synthesis	Synthesis	Synthesis
Evaluation	Evaluation	Evaluation	Evaluation

Source: Adopted from Pratama & Retnawati (2018)

The current study makes use of Yen and Abosalems' categorization of higher order cognitive skills. Yen categorised the levels of application. Students who operate at the levels of knowledge and understanding just recollect facts about a concept. On the other hand, a student is said to be operating at the application level when he is able to successfully transfer what is learnt or make practical sense of what he has been taught. This normally occurs outside the classroom settings.

Furthermore, at the level of analysis, students have to break a whole into bits and pieces in order to make meaning out of it. The level of synthesis is also known as creative behaviour where students would have to put bits and pieces together to make a meaning out of it. It could be concepts students have not encountered before whether inside the class or outside. Judgements are made at the evaluation level based on a defined criteria or standards.

There have been a lot of attempts globally on how best mathematics educators can effectively incorporate aspects such as communication and collaboration which are dubbed into their lessons in order to make it a project or problem-solving based lessons. The efforts of entities and organisations worldwide lead to collaborations among these groups that resulted in the formation of what

they call the "four C''. In this framework, it has been revealed that topics actually interrelate with each other to give meaning to concepts". In the Ghanaian context, implementing these 21st Century skills may require that a lot of obstacles have to be overcome. A number of hindrances are as outlined: The classroom settings of most of the senior high schools in the country: This has to do with the sitting arrangement of tables and chairs. In a typical Ghanaian classroom, where students are virtually overcrowded, it makes it almost impossible to make an adjustment of students sitting arrangement to aid students to comfortably learn from each other in group projects.

Issues with the core mathematics syllabus: The contents of the core mathematics syllabus have been arranged in such a way that, it appears the topics are disconnected and this has created a gap in students' ability to link concepts in order to solve daily life problems. For instance, sets and operations on sets is the first topic students are first exposed to. Conversely, embedded in it are concepts of probability, equations, and algebraic expressions which are to be taught later in SHS 1, 2 and 3.

Lack of resources in our various senior high schools: Many schools are handicapped in providing their mathematics teachers the best of materials in order to give students the best of stimulus during mathematics lessons. Basic textbooks are even lacking in some schools and not to talk of modern gadgets to be used in the classrooms elsewhere to aid teaching and learning (Kuranchie, Nanyele, & Owusu-Addo, 2018).

How HOCD is develop and assessment procedure done goes a long way to aid students in becoming more proficient in problem solving strategies, increase students' capacity in solving problems involving mathematics, and

enables students to handle daily life activities. Research conducted by Hamaker (1986) reveals that questions tailored towards HOCD provides students with a broader cognitive capacity as compared to those which simply recalls facts. It has been suggested by Andre (1987) that students are in a better position and more likely to recollect facts from a given text due to the amount of effort spent in processing the information. For this reason, much prominence must be given to how best to teach and assess our students in HOCD. One of the most broadly used criteria for classification of questions into the exact cognitive domain it measures is the Bloom's Taxonomy.

According to Dettmer (2006), there have been many wide applications of Bloom's taxonomy with regards to the alignment of what a particular program seeks to achieve. For instance, McBain (2011) made use of Bloom's taxonomy in the evaluation of learners' abilities in problem-solving through the assessment of their cognitive levels. The study was aimed at examining the amount of task students have been able to accomplish in terms of HOCD. It was concluded that a larger group of students exhibited competence in the LOCD whilst a smaller group of students exhibited mastery in HOCD.

Reviewing of Studies Related to the Study

Karns, Burton, and Martin (1983) adopted the content analysis design to look at the principles of economics in the manual given to instructors. It was revealed that most of the questions in the manual were not aligned to the objectives of the course outline and the questions were geared towards assessing students on HOCD to the neglect of LOCD.

On the results of the study, it is quite frightening and alarming that questions in a national learning material such as textbook or syllabus place

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much emphasis on the LOCD with an outright neglect of the HOCD. Ultimately, one would not be wrong to say that substandard products of the syllabus are channelled out into the society who will lack the needed skills to make impact in this globally competitive world of ours.

A considerable number of studies exist in literature on the content validity of national examinations with various approaches and designs. One of such studies was conducted by Amajuoyi, Eme, and Udoh (2013) whose work looked at how valid WASSCE chemistry was in terms of content. They concluded that much emphasis was put on some topics whilst other topics were completely overlooked. They further revealed that most of the questions placed emphasis on LOCD instead of HOCD.

Another study was done by Issa, Oyelekan, and Upahi (2015) in analyzing questions relating to chemistry in an attempt to identify HOCS. The basis of their study was to determine whether these summative assessments aligned with the current reforms in science education that advocate for High Order Cognitive Skills assessment methodologies in science education. Their findings were that out of the total cognitive process skills assessed by the chemistry questions for the period of five years, from 2010–2014, a handful of questions which amounts to 20% measured HOCS. The remaining 80% of the examination questions measured Lower Order Cognitive Skills.

These results are reasonably consistent with the results in the study conducted by Tsaparlis and Zoller (2003), but goes contrary to the results obtained by Tikkanen and Aksela (2012) on their work on Finnish chemistry matriculation examination. The study by Tikkanen and Aksela on summative assessment in chemistry reported that, a bigger percentage of the Finnish

chemistry matriculation examination questions dully measured HOCS. However, some inconsistencies were noted when the findings of this study revealed a higher percentage of the questions falling into the category of LOCS, principally, 36.5% of the test items being placed in the category of remembering.

Further studies by Ibrahim (1998) sought to analyse the questions contained in a history book. It was revealed that the questions measured up to 72% of cognitive level of knowledge. Evaluation questions took only 2.2%. Strangely, no question was asked on application, analysis and synthesis. The study provides a clue for thorough investigations into national teaching materials such as the textbooks and how they influence national examinations. Investigations into national examinations have become very imperative as it directly reflects the syllabus standards of the country in perspective. The study did not take into account the questions in the national examination as aligned with the prospect of the national syllabus and that is why the current study is very important.

Puluhulawa's (2018) did a study on the Analysis of 2010 Japanese Senior High School National Examination. The knowledge types in the 2010 Senior High School National Examination were investigated. Descriptive qualitative design was used for investigations. The result indicated that objective questions that called for higher cognitive reasoning rather demanded on students to use theories to answer. It is well documented that multiple choice questions do not give students the luxury of time and space to express their views through which their cognitive competence could be well measured. It was reported after the analysis that, almost all the test items fell in the

Understanding Level. The study had limitation in assessing students only on multiple questions and in furtherance to the study, other research design was recommended. It is due to this recommendation that the current study made use of both objectives (multiple choice) and theory questions. Again, the current study made use of content analysis research design instead of a descriptive design. In qualitative research, descriptive and content analyses are some of the designs a researcher could use.

Recently, a study was done by Ayoade (2016) on Comparison between WASSCE and NECO chemistry questions in the periods 2008-2012 revealed a huge disparity in the mode of assessment of the two examination bodies. Categorization of questions was done in reference to the work of Bloom. Just like the current study, the previous study made use of secondary data consisting of past questions.

Joseph's (2000) study was on the classification of SSCE chemistry questions. The study also sought to ascertain the validity of national examinations conducted by WAEC. It is only necessary to verify the reliability and the face validation of these examinations. It is on the premise of the findings and recommendations that the current study seeks to investigate how the core mathematics examination questions constructed by WAEC reflect the objectives and the dictates of the core mathematics syllabus.

Lately, Yibrah (2017) conducted a study in assessing the validity of Ethiopian English examinations (EGSECE) in terms of content observed problems of adequate sampling of test items. The study made use of both qualitative and quantitative research designs. Content analysis was specifically used. The study revealed that the questions failed to reflect the syllabus in

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terms adequate test item representation. One of the recommendations made was for stakeholders in the educational settings to look into the standards of national examinations with regards to its content validity. The current study seeks to go into such a suggestion by also using content analysis design but considering core mathematics at the SHS level.

The work of Sibomana (2016) who conducted a study on how reflective the syllabus: Rwanda ordinary level with respect to their English examinations reported that the contents of the national English examinations and the national syllabus were aligned. The researcher made use of content analysis research design with 2009, 2010 and 2011 examination questions as the data. The results revealed a harmonious relationship between the syllabus and the examinations. By this, the results pointed out the closeness and a mutual relationship between the curriculum and the examination. The study further suggested a more comprehensive content validity study on other national examinations.

At the lower educational level, Pantzare (2018) conducted a study on dimensions of validity studies of the Swedish national tests in mathematics, reported item and sampling validity of the national mathematics tests. The study made use of triangulation approach to analyse the results and recommended that further and expanded study has to be conducted on a large-scale national examination with a different research method.

Awanta (2005) conducted a study to examine the link between the Basic Education Certificate Examination (BECE) and the mathematics syllabus standards in Ghana. Data for the study were past BECE mathematics questions spanning between 1992 and 1999. Unlike the current study which

analysed all questions from 2009 to 2019, the study made use of two BECE examination papers: one paper from 1992 and the other from 1999. It was reported that the BECE mathematics questions were aligned to lower knowledge types and not evenly spread across the topics.

Winter as cited by Awanta (2005) reported on how teachers teach to test instead of adequately preparing students for their future endeavours. This is mostly done by solving of past questions that usually appear in the examinations. Also, students are coached on how to answer questions instead of guiding them. The study provided a clue for further studies on a large number of questions.

A closer look at the afore-reviewed literature on content validity of national examinations reveals that all may not be well with the WASSCE core mathematics questions yet little or no study has been conducted on the validity of WASSCE core mathematics questions, hence, the need for this study.
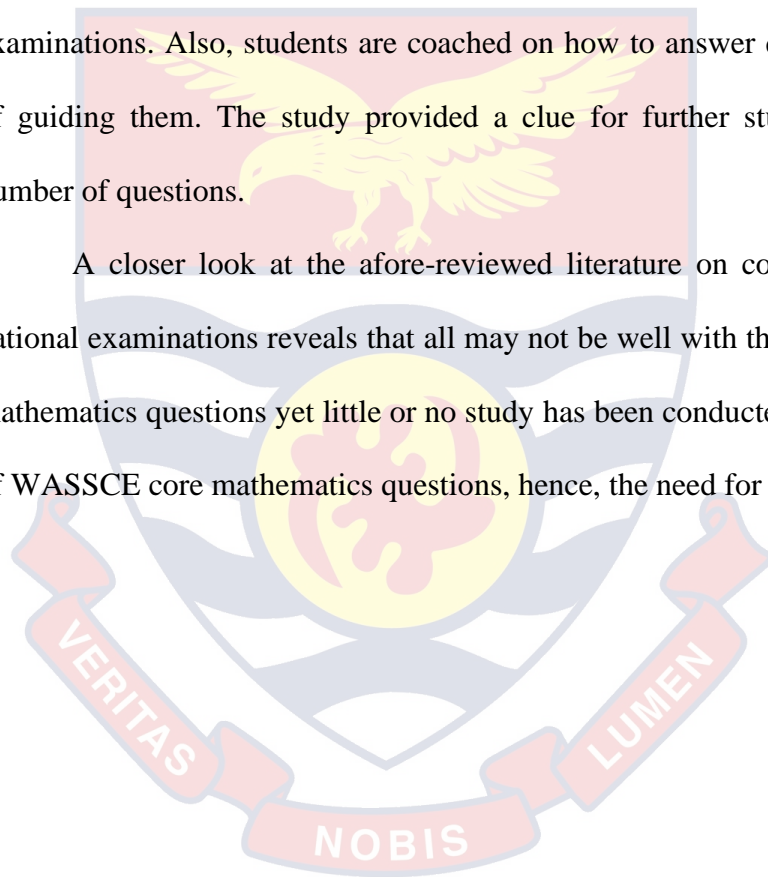
CHAPTER THREE

RESEARCH METHODS

The study aims at investigating the past questions of WASSCE core mathematics in order to ascertain if the mode of assessments conforms to that which is prescribed in the GES syllabus. It is by this that a sound judgement could be made on students' results. This chapter describes the design used for the study and the reason for the choice. Important areas covered include the Area of study, Population of the study, the sampling approach used, instruments used for collecting data, how the validity and reliability of the instruments were done and how the data was processed and analysed.

Research Design

According to Denzin and Lincoln (2005) research design is defined as a strategy that is chosen to suit the kind of research question one seeks to answer and what is being investigated.

The qualitative design as used in this study is explained by Ferreirra, Mouton, Puth, Schurink, and Schurink (1998) as more of exploring and describing a pattern rather than just providing explanations. Meyer (2000) is of the view that descriptive qualitative research helps readers to follow with keen interest in an attempt to grasp a deeper meaning of the problem.

In addition, the study incorporates content analysis because examination papers will be collected and analysed. Qualitative design and content analysis as research methods were adopted for this study. This was so because of the nature of the data being past examination questions and the nature of the research which is purely document analysis and interpretations. From Berelson (1952) perspective, content analysis could be explained as "a

research technique for the objective, systematic and quantitative description of the manifest content of communication". It primarily revolves on observation and narrative. This study makes use of aspects of content analysis where the number of times a particular content appears would be counted and the relationship among contents examined.

In this study, the terms in the data, being past questions are explicit in nature and this makes coding easier. The coding is done by counting the number of times content appears. Content analysis begins with what entails in the research questions. Every research question comes with its own terms to be coded. Coding is done by hand because of the explicit nature of the data in this study.

Some past WASSCE core mathematics examination papers were analysed in order to determine whether the questions reflected the core mathematics syllabus standards or not. The analysis of the examination questions provided information for the establishment of whether or not the WASSCE core mathematics questions reflect the syllabus standards in Ghana.

Study Area

WAEC comprises of five member Anglophone countries namely Ghana, Nigeria, Gambia and Sierra Leone being the first four members and later joined by Liberia. Senior high school students in these countries sit to write the WASSCE core mathematics papers every year. Nevertheless, the study is applicable in Ghanaian setting because core mathematics syllabus provided by the Ghana Education Service was used for this study.

Population

According to Cooper and Schindler (2006); Parahoo (2014), population is said to be the totality of a group of people, events and items or objects the researcher is interested in. In this study, the population consists of all the May/June WASSCE core mathematics questions. The question papers are mainly objectives and theory and it will serve as a premise of data.

The data for this study was obtained from the Ghana Education Service by privilege of being a mathematics teacher in a senior high school. The data comes in a form of past questions. Topics from the Core mathematics Syllabus and the WASSCE Examination papers constituted the data for this study.

Sampling Procedure

Due to the nature of the data, purposive sampling technique was employed. In qualitative designs, purposive sampling technique which is a deliberate choice of the researcher is used to explore and obtain a depth of understanding of a phenomenon. WASSCE Core mathematics questions inclusive of 2009 to 2019were purposively selected since according to Rosenberg (1997), 10 years is enough for any data trend analysis. Besides, this period constitutes current WASSCE questions.

A total of 707 WASSCE core mathematics questions from 2009 to 2019, excluding 2010 formed the sample of the study. The questions were made up of 500 multiple choice questions across the ten-year period under study. There were 203 theory questions in all. The theory questions have sub questions and if the sub questions were picked from different content areas (topics), they were counted separately. If the sub questions all come from the same content area (topic) then they were all counted as one for that question.

There were four questions that could not be classified under any of the Ghana Education Service (GES) teaching syllabus and so were classified as 'outside questions'. This brings the total sample to 707.Weighting of questions did not form part of the means of counting or coding questions because weighting of questions based on marks assigned to them is not applicable in this study. This study did not cover item discrimination and item difficulty index. Coding or counting of questions was done using '1' and '0' as indication of the presence and absence of a question under a particular topic respectively. The researcher did not in any way attempt to weigh the questions because that would mean a deviation from the focus of the study. Most significantly, the researcher is only interested in the spread of the questions over the syllabus topics and the knowledge type the questions seek to measure. Ten-year period was used as the basis for obtaining the sample size because same format of questions is being used by WAEC since 2009.

Data Collection Instruments

The major documents used by the researcher are the GES core mathematics syllabus, WAEC syllabus, and Chief examiner's reports. Data collection instruments are organized in the form of data sheets. Table 2 is a data sheet used as an instrument to collect information on percentage spread of topics in the syllabus for answering research question one.

Table 2: Data Sheet for Percentage Spread of Core Mathematics Topics by Year

S/N	Topics	Year									
		09	11	12	13	14	15	16	17	18	19
1	Sets										
2	Real no										
3	Alg. Expr										
4	Surds										
5	No Bases										
6	Relat/func										
7	P/ geom.										
8	Eqn/Ineqn										
9	Bearings										
10	Statistics										
11	Transform										
12	Enlargemt										
13	Ratio										
14	Percent										
15	Sequences										
16	Modulo										
17	Indices/log										
18	Simult.eqn										
19	Variation										
20	Mensuratn										
21	Trig.										
22	Constructn										
23	Log/Reas										
24	Quad/func										
	*Outside										

Source: Adopted from GES Core Mathematics Syllabus

The data sheet in Table 2 was designed using the GES core mathematics syllabus. The core mathematics syllabus has 29 topics

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comprising of thirteen (13) units in SHS 1, twelve (12) units in SHS 2 and four (4) units in SHS 3. For the purpose of page layout orientation, topics which are fragmented as I and II have been merged and captured as one topic. These are percentage I and II, trigonometry I and II, plane geometry I and II, enlargement I and II and mensuration I and II. This reduced the number of topics in the GES syllabus from 29 to 24. The sheet shows how topics in the core mathematics syllabus have been arranged in order in which they appear from Sets and operations on set in SHS1to Logical reasoning in SHS 3.

Questions not found in the GES syllabus are captured as "Outside''. Sequence and series is captured as Sequence, Logical reasoning is captured as Log/Reas while Number bases are captured as No bases, construction is captured as Constructn. Simultaneous equation is captured as Simult/eqn while Percentages is captured as Percent. Transformation, comprising of rigid motion I and II is captured as Transform; Trigonometry is captured as "Trig'', Ratio and rates is captured as Ratio, while Indices and Logarithm is captured as Indices/Log. Equations and inequalities is captured as "Eqn/Ineqn''. Quadratic function is captured as Quad/func. Real number system is captured as Real no, Relation and function is captured as Relat/func while Algebraic expressions is captured as Alg. Expr, Plane geometry is captured as P/geom; Mensuration is captured as Mensuratn while Statistics I and II is captured as Statistics. The period under study which is 2009, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019 are captured as 09, 11, 12, 13, 14, 15, 16, 17, 18 and 19 respectively.

Validity and Reliability

Validity has to do with the degree with which a test achieves its purpose of assessment. A test is judged as valid if it achieves its intended purpose. (Hathcoat, 2013). How reliable a test is can also be defined as the dependability or trustworthy of a test. Reliability exists in different forms assuch as Test-retest, Parallel, and Inter-rater. The later featured prominently in the current study. Employing the services of two or more judges to rate a work becomes very useful because there is a human factor in everything especially when items they are supposed to classify borders more on subjectivity. The services of two judges were sought to inter-rate 30 of the past questions with the researcher in terms of the construct they seek to measure.

The calculation of the reliability coefficient of the normal data was made possible when ten core mathematics WASSCE papers; one from each year was purposely selected for face validation and inter-rater consistency. Thirty multiple-choice objective questions were simple randomly selected across the year groups. It is understandable because objective questions amount to 500 in number out of the possible 703 minus the 4 'outside questions' representing 71.12%. All the 29 topics in the teaching syllabus were represented in the 30 objectives questions used for face validation and inter-rater agreement. The 30 objectives questions were subjected to classification in order to verify the kind of knowledge type each seeks to measure. They were further probed by experts in measurement and evaluation who subsequently face validated it. The 30 questions used in the pilot testing had 26 agreements on the type of topic as well as the specific knowledge domain the questions assess. Four examples that follow were part of 30

questions selected for pilot testing and the agreement reached by the two judges. (See Appendix B, for the 30 questions). The code '1' and '0' indicates agreement and disagreement between the two judges respectively.

Example 1: Objective Question 14 (Paper 1) for 2013 reads: If

$x^2 + 1(x - 2)(x + 1) = 0$. Find the value of x.

Judge 1 placed it under quadratic equation and measures LOCD and Judge 2 also placed it under quadratic equation and measures LOCD. Since the two judges were in agreement it was rated with code 1. Where there was no agreement, the rating code was 0.

Example 2: 2016 Objective Question 39 was "If 20(mod 9) is equivalent to y (mod 6), find y".

Judge 1 placed it under Modulo Arithmetic and measures HOCD while Judge 2 also placed it under modulo Arithmetic HOCD. The rating code here was 1.

Example 3: 2015 Objective Question 5 was "Find the 7th term of the sequence".

 Both judge 1 and judge 2 placed the question under LOCD. The coding code was 1 because both agreed.

Example 4: 2017 Objective Question 9 was "Solve the equation

$\frac{1}{5x} + \frac{1}{x} = 3$". Both judge 1 and judge 2 placed the question under LOCD. The coding code was 1 because both agreed.

Because there were 26 (out of 30) total agreements reached by both judges on the type of topic as well as the specific knowledge domain the questions assess, the calculation of the reliability coefficient yields

$$\text{Reliability coefficient} = \frac{\text{sum of aggreements}}{\text{sum of possible agreements}} \text{x } 100\%$$

$$= \frac{26}{30} \text{ x } 100\% = 86.7\% \text{ or } 0.87$$

Thus, the computed value of **0.87** represents the level of agreement between the two raters and the researcher, and according to Glen (2016) this value is of standard.

GES Core Mathematics Syllabus

The core mathematics syllabus is a document provided by Ghana Education Service to all core mathematics teachers in the various senior high schools. The syllabus which served as a guide for the WASSCE core mathematics questions has remained the same over the period of the study. It is the official document which spells out the topics to be taught for the three-year period that the student will be in school. It further suggests some teaching methods that may be suitable for the lesson and teaching and learning activities as well. Suggestive questions for each topic are also stated to guide teachers on the kind of task the students are meant to be engaged with. Core mathematics papers between the periods of 2009-2019 provided the topics for the categorization. In all, there were 707 questions consisting of Paper 1 (Objective test) and Paper 2 (Essay).

The type of cognitive demand as portrayed by the questions comes with action verbs which helped the researcher in classifying the 707 WASSCE core mathematics questions as either higher or lower cognitive domains. The display in Table 3 is an abridged structure of the GES core mathematics syllabus for topics from SHS 1 to SHS 3. This excludes the objectives and learner activities as well as evaluation for each topic.

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Table 3: Topics by Year in GES Core Mathematics Syllabus

UNITS	S.H.S. 1	S.H.S. 2	S.H.S. 3
1	Sets	Modulo	Mensuratn
2	Real No	Indices /log	Log /Reas
3	Alg. Expr.	Sequences	Trig
4	Surds	Percent	
5	No bases	Variation	
6	Relat / funct	Statistics	
7	Construction	Quad/ func	
8	Eqn /ineqn	Mensuratn	
9	Statistics	P/Geom	
10	Enlargemt	Trig	
11	Ratio	Simult/eqn	
12	Percent	Enlargemt	
13	P/Geom		

Source: Adopted from GES core mathematics syllabus

The topics in the core mathematics syllabus have been sequenced in a manner that makes teaching and learning flexible and meaningful. That is increasing complexity from SHS1 to SHS 3. Teachers who handle core mathematics are supposed to complete at least four topics in every term in the academic year. The syllabus as an instrument helps in assessing the content coverage or the spread of the WASSCE core mathematics questions. The examination questions are analysed across all topics in the syllabus to locate where exactly to place them. Questions which could not be placed under any topic would be described as "outside questions"

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Data Collection Procedure

The data for this study being WASSCE core mathematics questions is a secondary data which exist as a public document. It was collected personally by the researcher in November, 2019 in a form of past questions distributed by the government to all senior high school mathematics teachers. Data sheet was used to collect the frequencies for the topics in the examination papers within the 10-year period. The GES syllabus was used to identify the topics as seen in the data sheet in Table 2.

The chief examiners' reports were collected by downloading it from http://www.myschoolgist.com.ng by the researcher in February, 2020. It is mostly made available to teachers in the Senior High Schools after every WASSCE in order to serve as a guide on what is expected of students in their subsequent WASSCE.

Data Processing and Analysis

The data processing approach for this qualitative research was done using frequency distribution. Coding was done in the form of counting the number of times a particular item or question appears under a particular topic. If a topic has no question appearing under it in a particular year, it was coded as '0' but the presence of a question under a particular topic was marked '1'. This was used to answer research question one on the spread of topics in percentage terms in the GES core mathematics syllabus as observed in the 2009 to 2019 WASSCE core mathematics questions. The seven hundred and seven (707) questions from WASSCE core mathematics papers covering 2009 to 2019 were classifiedinto higher order and lower order cognitive domains.

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The data sheets were organised on specifications on profile dimensions being 30% and 70% for lower cognitive order and higher cognitive order respectively. This method of classification was done with the guidance of Chang and Chung's (2009) report where they argue that classification of questions into the knowledge types could be done through the use of 'action verbs' contained in the question and or the nature of the questions. The latter criterion is used when there is an absence of any 'action verb' in the questions.

Data on classification of items into LOCD and HOCD was analysed by checking the number of items that fall under each category for each year and later computing the percentage spread for the years bearing in mind the 30:70 ratio for profile dimensions indicated in the GES core mathematics syllabus. This was used to answer research question two on the percentage representations of higher and lower order cognitive domains in the 2009 to 2019 WASSCE core mathematics questions.

The past performance rates over the ten (10) year period were used as against the LOCD and HOCD spread for each of the years to determine if there is any relationship. This was used to answer research question three on the relationships between the trend of students' performance and the cognitive domains levels in the 2009 to 2019 WASSCE core mathematics questions.

Chapter Summary

This chapter explained the research methodology adopted for this study. This study does not provide comprehensive validity investigations into the validity of core mathematics WASSCE questions. Only content validity evidence was explored, hence only partial validity evidence was to be generated. One possible limitation is the subjective nature in classifying the

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questions under various topics as well as the knowledge type, they seek to measure.

Conclusion

From the discussions, one is likely to appreciate that for a teacher or an examiner to carry out a standardised achievement test that is content valid, guidelines such as knowing the purpose of the test, and analysing the contents of the GES core mathematics syllabus is very important. For example, comprehensive achievement test would lack content validity if the questions assess one aspect of the topics in the syllabus.

The purpose of educating students is to prepare them to face and excel in life challenging tasks. They can only do so when they are made to undertake higher order cognitive tasks in the course of their daily learning activities. By that, they will be able to draw similarities of what is learnt in the classroom and what they will face in their real life.
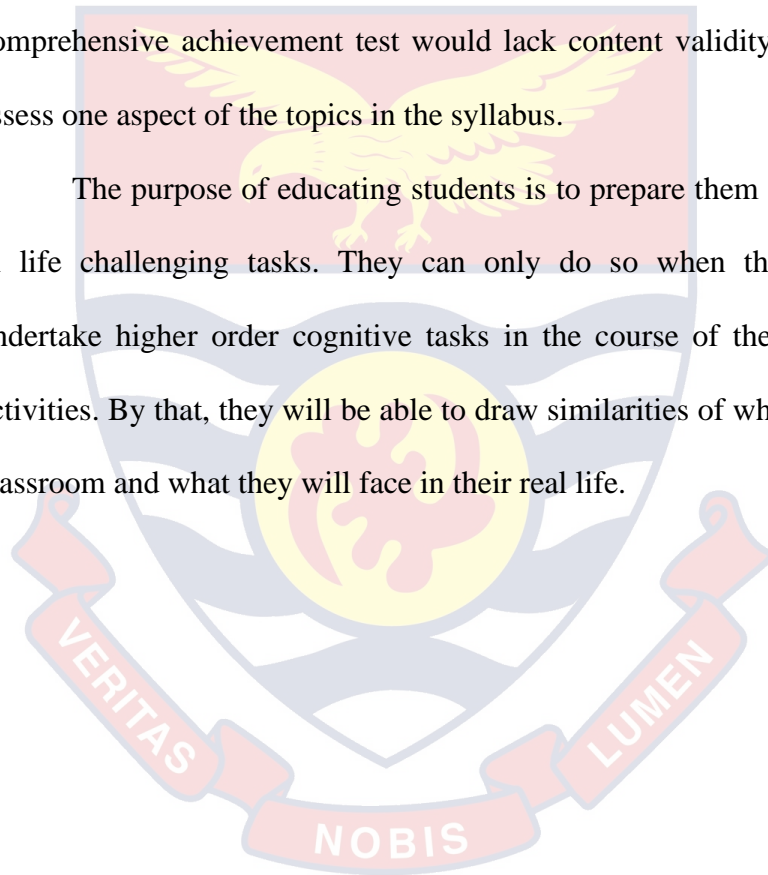
CHAPTER FOUR

RESULTS AND DISCUSSION

The primary purpose of this study is to investigate whether or not the WASSCE core mathematics questions by WAEC is a true reflection of what is stipulated in the core mathematics syllabus for senior high schools in Ghana. The study focused on the WASSCE core mathematics questions, given that the scores generated are being used as part of total standard score for making selection decisions. It is therefore imperative for an evaluation of the appropriateness of test score interpretations made on students' achievement in the WASSCE core mathematics so as to establish the soundness of that interpretation. Only content validity evidence is collected and used in the validity argument.

For the purpose of this research, the research paradigm followed is qualitative innature; it makes use of content analysis in that some past questions were sampled which is representative of the total number of questions. Frequency distribution tables and percentages were used in analyzing the data collected. This was because the focus of the research was to look at how WASSCE core mathematics questions were distributed across the years spanning 2009-2019. In order to assess the spread of the WASSCE core mathematics questions across the 29 topics, within and across the years, frequency distribution tables and percentages were best fit for the collection and analysis of data. Seven hundred and seven WASSCE core mathematics questions covering both paper 1 and paper 2 were investigated in this study. Students are expected to answer all 50 objectives (multiple-choice) questions in paper 1, as well as 10 out of 13 essay questions from Paper 2. The theory

questions which are the paper 2 are constructed in two sections; Part I and Part II. Part I normally consist of not more than 6 questions of which students are compulsorily asked to attempt all whilst the Part II consist of questions usually not more than 7 and students are obliged to attempt 4 in order to have any hope of being successful in the core mathematics WASSCE. Occasionally, some questions are a preserved for either Ghanaian students or other nationals. Such questions were not considered in this study. Time allocation of 1 hour and 2 hours 30 minutes are assigned to the objectives and theory sections respectively.

The presentation of the results in the chapter is done in line with the research questions formulated to guide the research.

Research Question 1: What is the percentage of spread of topics in core mathematics syllabus as represented in the 2009-2019 WASSCE core mathematics questions?

Data collected to answer research question one on how the WASSCE core mathematics questions within the investigating period of 2009-2019 are spread across the topics in the GES core mathematics syllabus is presented in Table 4. The table is organised under five columns of Topics, the table also features an important indicator which is the Number of objectives (obj.) identified for each topic in the GES syllabus, the specific learning objectives as contained in the GES core mathematics syllabus clearly indicates the voluminous nature of the topics, Year of examination, from 2009 to 2019 excluding 2010 is captured as 09, 11, 12,13,14,15,16,17,18 and 19 respectively, total spread and percentage spread. The column for the number of specific objectives is highlighted to make it distinct.

Table 4: Percentage Spread of Core mathematics Topics by Year

Topics	No. of obj.	Year of Examination										Total Spread	%
		09	11	12	13	14	15	16	17	18	19		
P/geom.	13	20	25	28	12	18	18	21	20	22	18	210	29.70
Mensuratn.	14	8	7	1	10	09	10	08	5	4	7	68	9.62
Statistics	8	8	6	0	4	8	6	6	8	5	0	51	7.21
Quad/func.	8	4	6	6	4	4	4	4	5	4	2	49	6.92
Alg. Expr.	7	4	5	4	5	4	4	4	3	4	5	42	5.94
Percent	11	3	6	6	6	3	3	7	4	1	1	40	5.66
Real No	9	3	4	6	4	5	2	3	3	3	5	36	5.09
Eqn/Ineqn.	5	5	1	1	5	5	5	2	5	2	2	34	4.81
Relat/func.	8	1	1	3	3	3	2	2	3	4	4	24	3.39
Indices/log	5	4	2	3	3	1	2	3	2	1	3	22	3.12
Trig.	8	0	0	3	2	2	3	2	2	2	2	16	2.26
Sets	4	2	2	2	1	2	2	1	2	1	2	16	2.26
Ratio	6	1	1	2	3	1	1	0	5	1	1	15	2.13
Surds	3	1	2	1	1	2	1	1	1	2	2	14	1.98
Transform	8	0	1	1	0	3	1	3	0	3	1	13	1.84
Modulo	2	1	1	1	1	2	1	1	1	1	0	10	1.42
Variation	6	1	1	1	1	1	0	1	1	0	2	09	1.27
Construct	3	1	1	1	1	0	1	1	0	0	1	07	0.99
Bearing	12	0	1	1	0	2	0	1	1	1	0	07	0.99
No Bases	3	0	1	1	1	1	1	1	0	1	0	07	0.99
Simult/eqn	3	1	1	0	1	0	1	0	0	1	0	05	0.70
Log/Reas	4	0	0	0	0	0	1	1	1	1	0	04	0.57
Sequence	5	1	1	0	0	0	0	0	0	1	1	04	0.57
Outside	0	0	0	0	0	0	0	0	1	3	0	04	0.57

Source: Adapted from Amajuoyi *et al.* (2013)

Twenty-three topics are identified from the GES core mathematics syllabus as captured in Table 4. Plane geometry covers plane geometry I and

II. Plane geometry I as a unit in SHS1 has contents (subtopics) as angles at a point, triangles, polygons and quadrilaterals covering eight specific objectives. Plane geometry II as a unit in SHS 2 has contents (subtopics) such as locus, circle theorem and tangents covering five specific objectives.

Trigonometry covers Trigonometry I and trigonometry II. Trigonometry I as a unit in SHS2 has contents (subtopics) such as trigonometric ratios, angles of elevation and depression and has five specific objectives. Trigonometry II as a unit in SHS3 has contents such as graphs of trigonometric function and trigonometric equations and has two specific objectives.

Statistics comprises of Statistics I and Statistics II. Statistics I in SHS1 has contents covering frequency distribution, mean of a distribution and graphical representation of data with four specific objectives. Statistics II in SHS2 has contents covering histogram, mean, cumulative frequency curve, standard deviation and variance and has four specific objectives.

Percentage comprises of Percentage I and Percentage II. Percentage I in SHS1 has contents such as comparison of percentages, discount, commission, simple interest, and hire purchase and has three specific objectives. Percentage II in SHS2 has contents such as compound interest, depreciation, financial partnership, banking, income tax, hire purchase and value added tax and has six specific objectives.

Rigid motion I in SHS1 covers translation by a vector and reflection in a line and has three specific objectives. Rigid motion II and enlargement in SHS2 has covers rotational symmetry, rotation, enlargement, area, volume all with five (5) specific objectives.

Mensuration I and II as a unit in SHS2 has four specific objectives covering contents such as length of an arc, perimeter of a plane figure, areas of sector and segments, areas of quadrilaterals. Mensuration II in SHS3 covers nets of prisms, surface areas of prisms, volume of prisms, surface area of a cone, volume of a cone, and distances of arcs of spheres and has ten specific objectives.

Table 4 shows that out of the twenty-three topics (units) of the GES Core mathematics syllabus, there were 210 questions on Plane Geometry I and II alone out of the 707 questions under study. This represents the highest percentage of 29.70%. This was followed by Mensuration I and II with 68 items representing 9.62%. Statistics I and Statistics II with 51(7.21%) items and Quadratic function with 49 items representing 6.92% followed in that order. Logical reasoning and Sequence and series had the lowest percentage of 0.57% each.

Questions classified as 'outside questions' also represented 0.51% of the 707 questions captured for analysis over the ten-year period. These questions were on matrices and introductory calculus.

The high disparity between questions that fell under Plane Geometry and Mensuration and the other topics raises a lot of eyebrows. This obviously calls for some deliberate measures to be taken by all stakeholders especially WAEC in order to assess all topics proportionately. It could be argued that the high disparities were as a result of the higher number of subtopics attributed to topics such as plane geometry and mensuration. Be as it may, what then can be said of topics such as bearings, percentages, real number system, trigonometry, relation and function and transformation with equally high

number of subtopics? The total questions spread recorded under Plane geometry are more than 100% as that of Mensuration; the second placed topic. The table also shows that the four topics: - Plane Geometry (I & II), Mensuration (I & II), Statistics (I & II) and Quadratic function recorded a total of 378 questions out of the 707questions which represents 53.45% of spread.

A thorough analysis within each year group reveals another dimension of a pattern. In the analyses of the 2009 paper, plane geometry had 20 questions out of 69 questions representing 28.99% as against that of mensuration and statistics with 11.59% and 11.59% respectively. In 2011, plane geometry again had the highest representation of 25 questions out of 76 questions representing 32.89% as against that of mensuration and statistics at 9.21% and 7.89% respectively. Also, in the 2012 paper, plane geometry recorded 28 questions out of 73 representing 38.40% as against that of mensuration and statistics at 1.47% and 5.48% respectively. Again, in the 2013, plane geometry had 17.65% as against mensuration and statistics with14.71% and 5.88% respectively. Furthermore, in 2014, plane geometry recorded 23.64% whilst mensuration and statistics had 11.49% and 8.70% respectively. The 2015 paper saw mensuration recording 26.10% as against that of mensuration and statistics with 14.49% and 8.70% respectively. Same can be said of the 2016, 2017, 2018 and 2019 papers. The 2018- and 2019- year groups saw plane geometry once again recording highest number of questions at 32.355% and 39.39% respectively whilst mensuration; 5.88% and 10.61% and statistics; 7.35% and 6.06% respectively.

The results show that on yearly basis, plane geometry had the highest number of questions followed by mensuration and statistics in that order. It is

worrying to note that plane geometry leads with very high number of questions and in most cases, the difference is more than 100% as compared to the second and third most tested topics.

Teachers in the known of this trend are likely to cover plane geometry, mensuration and statistics and the students would be sure to pass. This assertion is supported by Steeves *et al.* (2002) that teachers have the tendency to cover areas they know students are most likely to be assessed.

One could argue that plane geometry, mensuration and statistics have higher number of questions assigned to them because they have higher number of subtopics as well as specific objectives in the teaching syllabus. This is not reflected in the representation for topics such as real number system, percentages, bearing which also have high number of subtopics as well as specific objectives. If proportional distribution of questions was done with the total number of specific objectives as the weight reference, then all the topics with more specific objectives should have about had equal number of questions assigned to them.

The distribution in Table 4 shows that there is a huge disproportion among topic representations in the WASSCE core mathematics questions. This confirms that the profile dimensions which are clearly spelt out in the GES syllabus have been disregarded. This can lead to inappropriate way of learning and thus create a gap in students' knowledge which may greatly affect their competence in mathematics and future endeavours in general. Moreover, this could lead to teaching to the test by teachers because students who are able to master Plane geometry, Mensuration, Statistics and Quadratic functions would be 53.45% better off. On the other hand, over the ten-year

period, logical reasoning which serves as a premise for most daily communication, arguments and analysis recorded just four questions which represent 0.57%.

For the four items classified as, 'Outside questions' two were in Paper 1 (multiple choice objectives) whilst the other two were essay questions in Paper 2. It is very disturbing that students would be assessed on test items they are not exposed to in the teaching and learning process. As insignificant as the number of 'outside questions' are, why must they be present in the first place? Because it could still affect the performance or the output of students since some of these questions come with high marks attached to them.

The results clearly show a lack of content validity which is consistent with Amajuoyi, Eme, and Udoh's (2013) whose work looked at how valid WASSCE chemistry was in terms of content. They concluded that much emphasis was put on some topics whilst other topics were completely overlooked. The results clearly show a lack of content validity because the 2009-2019 core mathematics WASSCE questions failed to adequately and proportionally represent all topics in the core mathematics syllabus. As such proper scientific inferences cannot be sufficiently made on the performance of students who sit for the WASSCE core mathematics examinations.

The results of this study affirm the study conducted by Yibrah (2017) on assessing the content validity of EGSEC English examinations, which reported problems of adequate sampling of test items. From the data analysis, the test items which are constructed by examiners of WAEC had little or no reflection on the content of the GES core mathematics syllabus.

Table 4 further shows the number of objectives emphasized under each topic by the GES core mathematics syllabus. The number of objectives emphasized under each topic/unit are to correlate with the number of assessment questions in the GES syllabus, one would then expect WAEC to adequately emphasise topics such as Bearing and Vectors in a plane, Percentages, Menstruation, Quadratic functions & equations, Construction and Real number system, Trigonometry, Relations & functions in view of their respective emphasis in the GES syllabus as well as their utility values to students' daily activities.

Questions outside the syllabus were as follows. Matrices, in 2017 question 13b) which reads "Given that M=$\begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}$ N=$\begin{bmatrix} m & x \\ n & y \end{bmatrix}$and MN=$\begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$, find the matrix N.

There was another in 2018, question 13b) which reads "Given that P=$\begin{bmatrix} y & 8 \\ 3 & 2 \end{bmatrix}$ Q=$\begin{bmatrix} -3 & -5 \\ -4 & x \end{bmatrix}$ and PQ=R, find the values of x, y and z". There was another question on Integration in paper 2 (Question 11) which reads "Evaluate $\int_1^3 (\frac{3+x^3+2x^4}{x^2})$ dx", in 2018.

These questions on Matrices and Determinants and Introductory Calculusare not from the GES Core Mathematics syllabus. The WAEC syllabus isexpected to be an examinable aspect of the GES syllabus; hence one would have expected it to be a subset of the GES syllabus. Unfortunately, this appears not to be the case.

The availability and accessibility of the WAEC syllabus is not easy for interested persons to come by even if a school wishes to purchase it for their mathematics teachers. WAECofficials however encourage teachers to stick to

the national core mathematics syllabus when in fact students could be assessed on other major topics outside the national syllabus. This could affect the performance of students in their WASSCE core mathematics examination through no fault of theirs. Poor performance of students comes about when some of these questions could be frightening enough to demoralise students.

Questions of concern are, "why would a national examination body have their own examinable syllabus which includes topics outside the national syllabus?" "Should a teacher wish to go through these topics with the students aside the national syllabus, will there be enough time for him/her and the students?''

A study conducted by Bosson-Amedenu (2018) on the impact of the syllabus used by WAEC in assessing the mathematical attainment of Ghanaian WASSCE candidates reported private candidates who were treated with both GES syllabus and WAEC syllabus outperformed their counterparts from public secondary schooltaught with the GES syllabus. Bosson-Amedenu added that, most of the teachers were not aware of the existence of WAEC syllabus and so he refutes what the WAEC syllabus seems to suggest that it is not important for core mathematics teachers to rely on the WAEC syllabus for teaching, when in fact, students would be assessed on some portions of topics from it. See Appendix A (http://www.myschoolgist.com.ng)

Topics like Matrices and Determinants, Financial arithmetic and Introductory Calculus marked with asterisks as topics only in the WAEC syllabus but not in the GES core mathematics syllabus. (See Appendix A), are highlighted for easy identification.

It will be highly unfair to just look at the number of the 'outside questions' to deem it insignificant without looking at the fact that marks attached to each of these questions were significant enough to make a student either fail or pass. Another significant factor to look at is that some of these questions are likely to attract the uninformed student who may waste all the time in an attempt to unravel the solution.

On the other hand, the well-informed students who may know that those questions were not taught under any topic in class would not dare attempt them thereby making the number of optional questions to choose from being reduced to less than eight from which to select five as in the case in 2017 and 2018.

Though students' performances were still poor in those years that students were not tested on outside questions, the presence of questions on topics students were not expected to learn can have its own interpretation of the WASSCE results. This is an indication of validity negligence on the test constructors within those peculiar years and thus proper scientific inferences cannot be made on the results of the test in those years.

Both the national core mathematics syllabus and the WAEC syllabus aim at providing students the necessary platform to be equipped with higher order cognitive competencies and skills to be able to adapt to the ever-transforming world. However, very little have been done to make this a reality.

The motive of examining students is to find out how much grasp or progress made in contents they have been taught. A test cannot hold itself to be content valid if it assesses students on items outside the core mathematics

syllabus. Davis (2001); McAleer (2001) also argue that how much contents a test covers defines its validity. All tested items must come from the content area students are aware of. The WASSCE core mathematics papers for the 2009 to 2019 have thus failed this test of item validity and sampling validity. The contents of the papers were not representative enough.

The Chief Examiners' Report

The Chief examiner's reports over the years seem to highlight some reoccurring impediments to students' output in the WASSCE core mathematics examination. This report is peculiar to the strengths and weaknesses of Ghanaian students and is one of the most important documents that teachers mostly rely on in order to ascertain the areas students are lacking.

Notwithstanding the importance of this document, most teachers do not appreciate its usage due to the untimely released of it couple with the fact that teachers are mostly in the rush to finish the mathematics syllabus with little or no time to look at the content of the chief examiners' report. In spite of the fact that there are some challenges as to how teachers make use of the report on yearly basis, its importance cannot be discounted.

In the Chief examiner's report (2018), the following strengths and weaknesses were identified; however, these are not peculiar to 2018 WASSCE alone but previous ones as well. The report listed some strengths and weaknesses of students in the WASSCE core mathematics over the years with regards to paper 2.

Some of the strengths of candidates include most students were able to:

1. use Venn diagram to solve probability problem,

2. solve quadratic relations by completing the table values.

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3. find values of a variable by using a given mean.

4. evaluate a binary operation when a set of numbers are defined.

5. express a vector in a column through the use of a midpoint.

Some weaknesses of the candidates include most students were unable to;

1. finding the values of a logarithm;

2. How to translate meaning statements from word to mathematical symbols and solving them.

3. use completing the square method in solving a quadratic equation;

4. handling questions involving two matrices and as well as financial mathematics;

The report further indicated some difficulties students encountered in an attempt to provide answers for some questions with regards to paper 2. Some of the weaknesses are;

1. Some students had serious issues in dealing with expressions relating to logarithms;

2. Most students had problems in interpreting word problems mathematically.

3. Majority of students failed to solve problems in geometry.

From the Chief examiner's report, it is worth noting that; solving problems involving financial mathematics and finding the product of two matrices; had to do with topics which were outside of the national core mathematics syllabus. Specifically, these topics candidates had challenges in answering correctly were contained in the WAEC syllabus but not in the GES core mathematics syllabus. Obviously, students' output would be greatly affected because of the inclusion of certain questions which affects

the validity of the test as in line with Hathcoat (2013). Again, the report also made mention of students' inability to solve questions in word problem or translate questions from word problem to mathematical statement. This is quite interesting because the core mathematics syllabus demands that, about 70% of the questions must test higher cognitive domain which the WASSCE core mathematics questions fail to do. Can students be blamed for these phenomena? On the other hand, the report shows candidates'strength is in areas or topics which are in the GES core mathematics syllabus. Indeed, it is only natural that students would exhibit mastery in areas they have been taught but may not show same competence in areas they have not come across in their course of study.

Research Question 2**:** What are the percentage representations of higher and lower order cognitive domains in the 2009-2019 WASSCE core mathematics questions?

Table 5 provides data gathered to answer research question two on percentage representations of higher and lower order cognitive domains. The table is organised into five columns of year, higher order cognitive domain (HOCD), lower order domain (LOCD), total spread and total percentage spread of the two knowledge types.

Table 5: The Spread of HOCD and LOCD in Percentages in WASSCE Core Mathematics Questions

Year	H.O.C.D	L.O.C.D	Total Spread	Total % H.O.C.D	Spread L.O.C.D
2009	6	69	75	8	92
2011	0	82	82	0	100
2012	1	87	88	1.14	98.86
2013	2	80	82	2.44	97.56
2014	1	83	84	1.19	98.81
2015	1	79	80	1.25	98.71
2016	2	79	81	2.47	97.53
2017	0	82	82	0	100
2018	4	67	71	5.63	97.34
2019	2	59	61	3.28	96.72

Source: Adapted from Amajuoyi *et al.* (2013)

The results in Table 5 indicate that none of the years recorded even 10% for items in higher order cognitive domain. The highest percentage ever recorded was 8% in 2009. All the years recorded over 90% for lower order cognitive domain with 2011 and 2017 recording the maximum 100%, indicating that there was no question classified under higher order cognitive domain. This is in sharp contrast to what the core mathematics syllabus stipulates; 30% and 70% for lower order and higher order cognitive domains respectively. The syllabus directs 30%:70% ratio of the profile dimensions and rationale for syllabus stresses critical thinking/ problem solving/ and

functional mathematics and therefore any form of assessment should stick to this.

As observed in the table, higher cognitive domain questions were woefully inadequate per the current study. The evidence of 19 questions which tested higher cognitive domain out of the total 707 questions involved in the study is the premise on which the researcher laid such claims. This is an affront to what is enshrined in the core mathematics syllabus by GES. Thusfor WASSCE core mathematics questions to be valid in content, it must assess students learning in all the core mathematics topics as well as a proportionate amount of the cognitive domains. By this, some teachers who come to know these occurrences may simply be disinterested in helping students through higher cognitive questions.

The results of this study can be interpreted that the WASSCE core mathematics questions do not reflect what is stated in the core mathematics syllabus in terms of profile dimensions. The results confirm the findings by Joseph (2000) who pointed out that majority of the questions students were tested on fell on lower cognitive knowledge and as such do not meet the standard required of a high-stakes examination.

The findings of the study revealed a higher percentage of the questions fall into the category of LOCS. This is in agreement with the findings made by Awanta (2005) who examined the link between the BECE and the mathematics syllabus standards in Ghana. He reported that the BECE mathematics questions were aligned to the lower knowledge types of learning.

Research Question 3: What is the relationship between the trend of percentage performances of students and the cognitive domain levels in the 2009-2019 WASSCE core mathematics questions?

Table 6 displays the pass rate of candidates in core mathematics in WASSCE in relation to the higher and lower order cognitive domains in the 2009-2019 WASSCE.

Table 6: Trend of Performance of Students and the Cognitive Domain Levels in the 2009-2019 WASSCE Core Mathematics Questions

Year	Performance %	HOCD %	LOCD %
2009	31.1	8	92
2011	46.0	0	100
2012	52.0	1.14	98.86
2013	36.3	2.44	97.56
2014	29.0	1.19	98.81
2015	23.9	1.25	98.75
2016	35.4	2.47	97.53
2017	42.73	0	100
2018	38.33	5.63	94.37
2019	65.31	3.28	96.7

Source: Adapted from Wonu and Zalmon (2017)

Table 6 reveals that the 2011 and 2017 WASSCE core mathematics questions recorded 0% assessment in higher cognitive domain and consequently, these two years recorded the second and third best performances of 46.0% and 42.73% respectively. The highest percentage pass of 65.31 % was recorded in 2019 with a corresponding 3.28 and 96.7 percentage ratings in

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higher order and lower order cognitive domains respectively. It would have been expected that the highest performance of students recorded would have come with it the lowest lower order cognitive domain due to the fact that a higher cognitive domain questionsoften demand much morethinking and thus seen to be difficult. This however is not the case in this study. It is worth mentioning that 2009 had the highest percentage (8%) of questions which tested higher order cognitive domain but the percentage pass was 31.1%. However, 2014 and 2015 have very low high order cognitive domain items but with percentage pass less than 30%.

The result is surprising because senior high students are at a stage where they need to be tested more on highly demanding questions. This is the surest means of adequately preparing them to face the real world. The reverse is the case in this study. Hence, the WASSCE Core mathematics questions under study is not content valid and the results is in agreement with findings of Onunkwo (1990) and Joseph (2000) who concluded that both the Junior School Certificate Examination (JSCE) and Senior School Certificate Examination (SSCE) lacks content validity.

Table 6 depicts inconsistent results with a corresponding inconsistent and unstable figure recorded in the column of higher and lower cognitive domains. This goes to confirm the conclusions by Musa and Dauda (2014) in their analysis of students performance in WASSCE that students performance were not stable and unpredictable. There is no direct and consistent relationship between the performance of students and the type of knowledge the WASSCE core mathematics questions measure.

Implications Based on the Results of the Study

Evidence suggests that when teachers become aware that an assessment of syllabus-based test are skewed to some few topics, they teach to test; that is, teaching students to master those topics and how to answer questions on those topics as well. This disposition has been expressed by Warren (2004) who argues that assessment constitutes the syllabus for learners and these determine their learning activities on the basis of assessment. Further, Ghanaian senior high schools are ranked based on their students'performance in WASSCE core mathematics. In addition, teachers' teaching competence is evaluated based on their learners' performance in WASSCE core mathematics examinations. So, failure for WAEC to examine learners' competence in all content areas may make learners and teachers neglect the teaching and learning of the least or non-examinable areas.

Thus, teachers are likely to teach to examinations, focusing on those aspects which have a significant number of questions appearing yearly in the syllabus and, therefore, the areas which are not examined (for example logical reasoning) may receive limited or no attention from teachers. Again, the presence of 'outside questions' clearly shows that, WAEC sets the WASSCE core mathematics questions with little or no regards to the national core mathematics syllabus.

Another source of worry in reference to the results has to do with how the WASSCE core mathematics failed to assess students in questions that demand higher cognitive competence. This may impede students' cognitive development and students may not be able to live up to their billing when tasked to do jobs that require higher level of thinking.

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Summary

The results of this study give credence to the work of Iwuji (1997) who stated that a student may fail a test not because of his inabilities but due to issues with the test itself. One of such issues is the validity of the test. From the study, topics in the core mathematics syllabus were not very well represented. Additionally, the questions mainly focused on the assessing student's abilities in the lower levels of learning. It is thus concluded that the WASSCE core mathematics questions within the period under study lacked content validity.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The motive of the study revolves on finding out if WASSCE core mathematics questions by WAEC are a true reflection of the demands by the core mathematics syllabus for senior high schools in Ghana. The study focused on the WASSCE core mathematics questions, given that the scores generated are being used in critical decisions making. It was therefore very necessary and imperative for a proper scrutiny of test results and judgements passed on students' achievement in WASSCE core mathematics so as to establish the soundness of that interpretation. Further, only content validity evidence was used in the validity argument. The study examined core mathematics papers within a period of a decade; from 2009 to 2019.

The research questions focused on the percentage of spread of the topics in the core mathematics syllabus as represented in the 2009-2019 WASSCE core mathematics questions; the percentage representations of higher and lower order cognitive domains in the 2009-2019 WASSCE core mathematics questions and the relationship between the trend of percentage performance of students and the cognitive domain levels.

The research paradigm employed was of qualitative nature, making use of content analysis where a group of items was studied by collecting and analysing data from only a few items which represent the entire group.It primarily revolved on observation and narrative.

Summary

The analysis of the data gathered revealed that topics in the core mathematics syllabus were poorly represented raising content validity issues. The presence of anomalous questions tagged as 'outside questions' in two of the WASSCE papers present some kind of worry as to how teachers should teach those topics not found in their syllabus.

The results further showed that the focus of the questions was on assessing students' lower cognitive ability which is not what the GES syllabus seeks to achieve.

Conclusions

Lack of content validity of the WASSCE core mathematics questions has serious implications which cannot be underestimated especially because of the usability of the results obtained from the test. Key decisions such as admission of students into higher academic institutions and placement of students into academic courses are done based on the grade students had in the WASSCE examinations of which the grade one had in core mathematics play a key role in these decisions.

The WASSCE core mathematics questions during the period under study are not adequately represented across the topics in the core mathematics syllabus.

Students' poor performances in the years that included questions from outside the GES syllabus may not be attributed to either highly cognitive demanding questions or seemingly easy questions.

That the WASSCE core mathematics questions focused on lower levels of cognitive domains to the neglect of higher cognitive domains, provides a very

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compelling situation for teachers, parents, students and all stakeholders involved in the delivery of quality education since students' lives and educational endeavours could have been truncated because of issues with the test items.

The results of the study give a worrying picture because teachers and students work tirelessly to complete the entire core mathematics syllabus but only to be assessed significantly in just a limited number of topics and mainly on lower cognitive levels.

Recommendations

Based on the results of this study, the following recommendations are made:

Ministry of Education, WAEC, Teacher Unions and other stakeholders must work out on the way forward as to which document the WASSCE core mathematics questions would be based on. This will help reduce the state of confusion students and teachers are plunged into during preparation for the WASSCE core mathematics examinations.

WAEC must lay emphasis on the adherence to the use of test blueprint by their examiners at the item construction stage and encourage its examiners to stick to the ratio of the profile dimensions as set out in the GES core mathematics syllabus.

Suggestions for Further Research

Further studies could be done in areas such as item discrimination and item difficulty indices of the WASSCE core mathematics examinations.

Again, other approaches such as using qualitative method through triangulation of results and by techniques of interviewing, observation and

questionnaire. Moreover, another research approach that could be employed for this is mixed quantitative and qualitative research design. The required data for the study could be collected using textbooks/syllabi, questionnaire and unstructured interview.

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APPENDICES
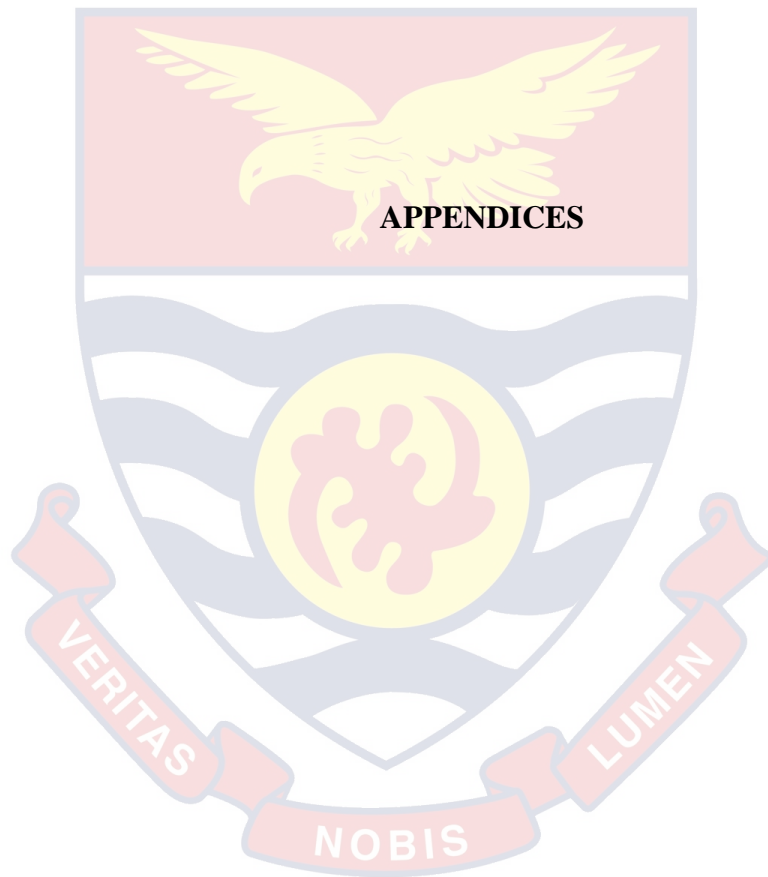
Appendix A

WAEC Core Mathematics Syllabus

Topics	Contents
A. Number and Numeration	i) conversion of numbers from one base to another
(a) Number bases	(ii) Basic operations on number bases
(b) modular arithmetic	(i) Concept of Modulo Arithmetic.
	(ii) Addition, subtraction and multiplication operations in modulo arithmetic.
	(iii) Application to daily life
(c) Fractions, Decimals and Approximations	(i) Basic operations on fractions and decimals.
	(ii) Approximations and significant figures.
(d) Indices	(i) Laws of indices
	(ii) Numbers in standard form (scientific notation)
(e) Logarithms	(i) Relationship between indices and logarithms e.g. $y = 10k$ implies $\log 10y = k$.
	(ii) Basic rules of logarithms e.g. $\log 10(pq) = \log 10p + \log 10q$ $\log 10(p/q) = \log 10p - \log 10q$ $\log 10pn = n\log 10p$.
	(iii) Use of tables of logarithms and antilogarithms.
(f) Sequence and Series	(i) Patterns of sequences.
	(ii) Arithmetic progression (A.P.) Geometric Progression (G.P.)

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(g) Sets	(i) Idea of sets, universal sets, finite and infinite sets, subsets, empty sets and disjoint sets. Idea of and notation for union, intersection and complement of sets.
	(ii) Solution of practical problems involving classification using Venn diagrams.
(h) Logical Reasoning	Simple statements. True and false statements. Negation of statements, implications.
(i) Positive and negative integers, rational numbers	The four basic operations on rational numbers.
j) Surds (Radicals)	Simplification and rationalization of simple surds.
(k) Matrices and Determinants ***	(i) Identification of order, notation and types of matrices. (ii) Addition, subtraction, scalar multiplication and multiplication of matrices. (iii) Determinant of a matrix
l) Ratio, Proportions and Rates	Ratio between two similar quantities. Proportion between two or more similar quantities. Financial partnerships, rates of work, costs, taxes, foreign exchange, density (e.g. population), mass, distance, time and speed.
(m) Percentages	Simple interest, commission, discount, depreciation, profit and loss, compound interest, hire purchase and percentage error.
(n) Financial Arithmetic ***	(i) Depreciation/ Amortization. (ii) Annuities (iii) Capital Market Instruments
(o) Variation	Direct, inverse, partial and joint variations.
B. Algebraic processes	i) Formulating algebraic expressions from given situations(ii) Evaluation of algebraic

Appendix A cont'd

(a)Algebraic expressions	Expressions
(b) Simple operations on algebraic expressions	(i) Expansion (ii) Factorization (iii) Binary Operations
(c) Solution of Linear Equations	(i) Linear equations in one Variable (ii) Simultaneous linear equations in two variables.
(d) Change of Subject of a Formula/Relation	(i) Change of subject of a formula/relation (ii) Substitution.
(e) Quadratic Equations	(i) Solution of quadratic equations (ii) Forming quadratic equation with given roots.(iii) Application of solution of quadratic equation in practical problems.
(f) Graphs of Linear and Quadratic functions.	(i) Interpretation of graphs, coordinate of points, table of values, drawing quadratic graphs and obtaining roots from graphs. (ii) Graphical solution of a pair of equations of the form:$y = ax2 + bx + c$ and $y = mx + k$(iii) Drawing tangents to curves to determine the gradient at a given point.
(g)Linear Inq.	(i) Solution of linear inequalities in one variable and representation on the number line.(ii) Graphical solution of linear inequalities in two variables.(iii) Graphical solution of simultaneous linear inequalities in two variables.
(h) Algebraic Fractions	Operations on algebraic fractions with: (i) Monomial denominators (ii) Binomial denominators

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(i) Functions and Relations	Types of Functions
C. Mensuration	(i) Use of Pythagoras theorem, sine and cosine
(a) Lengths and Perimeters	rules to determine lengths and distances.(ii) Lengths of arcs of circles, perimeters of sectors and segments.(iii) Longitudes and Latitudes.
(b) Areas	(i) Triangles and special quadrilaterals rectangles, parallelogram(ii) Circles, sectors and segments of circles.(iii) Surface areas of cubes, cuboids, cylinder, pyramids, right triangular prisms, cones and spheres.
(c) Volumes	(i) Volumes of cubes, cuboids, cylinders, cones, right pyramids and spheres. (ii) Volumes of similar solids
D. Plane geometry(a) Angles	i) Angles at a point add up to360o.(ii) Adjacent angles on a straight line are supplementary.(iii) Vertically opposite angles are equal.
(b) Angles and intercepts on parallel lines.	(i) Alternate angles are equal.(ii)Corresponding angles are equal.(iii)Interior opposite angles are supplementary(iv) Intercept theorem.
(c) **Triangles and Polygons.**	(i) The sum of the angles of a triangle is 2 right angles.(ii) The exterior angle of a triangle equals the sum of the two interior opposite angles.(iii) Congruent triangles. (iv) Properties of special triangles - Isosceles, equilateral, right-angled, etc(v) Properties of special quadrilaterals –parallelogram, rhombus, square, rectangle, trapezium.
	(vi)Properties of similar triangles. (vii) The sum of the angles of a polygon (viii) Property of exterior angles of a polygon.(ix) Parallelograms on the same base and between the same parallels are equal in area.

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(d) **Circles**	(i) Chords.(ii) The angle which an arc of a circle subtends at the centre of the circle is twice that which it subtends at any point on the remaining part of the circumference. (iii) Any angle subtended at the circumference by a diameter is a right angle.(iv) Angles in the same segment are equal.(v) Angles in opposite segments are supplementary. (vi) Perpendicularity of tangent and radius. (vii)If a tangent is drawn to a circle and from the point of contact a chord is drawn, each angle which this chord makes with the tangent is equal to the angle in the alternate segment
(e) **Construction**	(i) Bisectors of angles and line segments (ii) Line parallel or perpendicular to a given line.(iii)Angles e.g. 90o, 60o, 45o, 30o, and an angle equal to a given angle. (iv) Triangles and quadrilaterals from sufficient data.
(f) **Loci**	Knowledge of the loci listed below and their intersections in 2dimensions.(i) Points at a given distance from a given point.(ii) Points equidistant from two given points. (iii)Points equidistant from two given straight lines. (iv)Points at a given distance from a given straight line.
E. Coordinate Geometry of Straight lines	(i) Concept of the x-y plane.(ii) Coordinates of points on the x-y plane.
F. Trigonometry (a) Sine, Cosine and Tangent of an angle.	(i) Sine, Cosine and Tangent of acute angles. (ii) Use of tables of trigonometric ratios. (iii) Trigonometric ratios of 30o, 45o and 60o. (iv) Sine, cosine and tangent of angles from 0o to 360o.(v)Graphs of sine and cosine. (vi)Graphs of trigonometric ratios.

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(b) **Angles of elevation and Depression**	(i) Calculating angles of elevation and depression.(ii) Application to heights and Distances.
(c) **Bearings**	(i) Bearing of one point from another. (ii) Calculation of distances and Angles
G. Introductory Calculus***	(i) Differentiation of algebraic functions. (ii) Integration of simple Algebraic functions.
H. Statistics and Probability. (A) Statistics	(i) Frequency distribution(ii) Pie charts, bar charts, histograms and frequency polygons (iii) Mean, median and mode for both discrete and grouped data.(iv) Cumulative frequency curve(Ogive).(v) Measures of Dispersion: range, semi inter-quartile/inter quartile range, variance, mean deviation and standard deviation.
(b)probability	(i)experimental and theoretical probability (ii) addition of probabilities (iii) Multiplication of probabilities for independent events
I. Vectors and Transformation (a)Vectors in a Plane (b) Transformation in the Cartesian Plane	Vectors as a directed line segment. Cartesian components of a vector Magnitude of a vector, equal vectors, addition and subtraction of vectors, zero vector, parallel vectors, multiplication of a vector by scalar. Reflection of points and shapes in the Cartesian Plane. Rotation of points and shapes in the Cartesian Plane. Translation of points and shapes in the Cartesian Plane. Enlargement

Source: downloaded from www.myschoolgist.com.ng, (2020)

Appendix B

How Reliability was Established

Past questions	Judge 1	Judge 2	Agreement
1) 2013 OBJ. QUE. 14 If $x^2 + 1 - (x-2)(x+1) = 0.$ find the value of x	Falls under quadratic equation and measures LOCD	Falls under quadratic equation and measures LOCD	1
2) 2013 OBJ. QUE. 1 Solve the equation: $2^{(9x-3)} = 8^{(3-x)}$	Falls under indices and measures LOCD	Falls under indices and measures LOCD	1
3) 2013 OBJ. QUE. 6 If $4m4_{five} = 119_{ten}$ find the value of m.	Falls under number bases and measures LOCD	Falls under number bases and measures LOCD	1
4) 2014 OBJ. QUE. 1 Simplify $10\frac{2}{5} - 6\frac{2}{3} + 3$	Falls under Algebraic expressions and measures LOCD	Falls under Algebraic expressions and measures LOCD	1
5) 2014 OBJ. QUE. 6 Simplify: $\sqrt{12}(\sqrt{48} - \sqrt{3})$	Falls under surds and measures LOCD	Falls under surds and measures LOCD	1
6) 2014 OBJ. QUE 34 Approximate 0.0033780 to 3 significant figures.	Falls under significant figures and measures LOCD	Falls under significant figures and measures LOCD	1
7) 2015 OBJ. QUE. 5 Find the 7th term of the sequence	Falls under series and sequence and measures LOCD	Falls under series and sequence and measures LOCD	1
	Falls under	Falls under	

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8) 2015 OBJ. QUE. 8 Factorize completely: 6ax-12by-9ay+8bx.	quadratic equation and measures LOCD	quadratic equation and measures LOCD	1
9) 2015 OBJ. QUE.44. calculate the mean deviation of 5, 3, 0, 7,2,1	Falls under statistics and measures LOCD	Falls under statistics and measures LOCD	1
10) 2016 OBJ. QUE13. simplify: $\frac{2}{1-x} - \frac{1}{x}$	Falls under Algebraic expressions and measures LOCD	Falls under Algebraic expressions and measures LOCD	1
11) 2016 OBJ. QUE. 35 Express 1975 correct to 2 significant figures.	Falls under significant figures and measures LOCD	Falls under significant figures and measures LOCD	1
12) 2016 Obj. Que. 39 If 20(mod 9) is equivalent to y (mod 6). Find y.	Falls under modulo Arithmetic and measures HOCD	Falls under modulo Arithmetic and measures LOCD	0
13) 2017 OBJ. QUE. 9 Solve the equation $\frac{1}{5x} + \frac{1}{x} = 3$	Falls under linear equations and measures LOCD	Falls under linear equations and measures LOCD	1
14) 2017 OBJ. QUE. A bearing of 320^0 expressed as a compass bearing is	Falls under bearing and measures LOCD	Falls under bearing and measures LOCD	1
15) 2017 OBJ. QUE 47 Calculate the variance of	Falls under variation and	Falls under variation and	1

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	measures		
2, 3, 3, 4, 5, 5,5, 7,7,9.	LOCD	measures LOCD	
16) 2018 OBJ. QUE. 16 Which of the following about parallelogram is true?	Falls under mensuration and measures LOCD	Falls under mensuration and measures HOCD	0
2018 OBJ. QUE. 25 A fair coin is thrown once. What is the probability of obtaining 3?	Falls under probability and measures LOCD	Falls under probability and measures LOCD	1
17) 2018 OBJ. QUE. 4 Evaluate $\frac{4-\sqrt{2}}{\sqrt{2}}$			
18) 2018 OBJ. QUE. 9 Find the truth set of the equation $(x-2)^2 + 3 = (x+1)^2 - 6$	Falls under quadratic equation and measures LOCD	Falls under quadratic equation and measures LOCD	1
19) 2019 OBJ. QUE.2 Evaluate $(0.064)^{\frac{-1}{3}}$	Falls under real number system and measures LOCD	Falls under real number system and measures LOCD	1
20) 2019 OBJ. QUE.13 Solve $4x^2 - 16x + 15 = 0$	Falls under quadratic equation and measures LOCD	Falls under quadratic equation and measures LOCD	1
21) 2019 OBJ. QUE.21	Falls under function and	Falls under function and	1

Appendix B cont'd

	measures LOCD	measures LOCD	
Which of these values would make $\frac{3p-1}{p^2-p}$ undefined?	LOCD		
22)2009 OBJ. QUE. 5 If the logarithm of a number to base 10 is 26025, find the number.	Falls under logarithm and measures LOCD	Falls under logarithm equation and measures LOCD	1
23) 2009 OBJ. QUE.14 what should be added to $k^2 - \frac{1}{2}$k to make it perfect square?	Quadratic equations and measure HOCD	Algebraic expressions HOCD	0
24) 2009 OBJ. QUE.9 Find the value of x in the equations: 2x+2y = 3 x-y = $2\frac{1}{2}$	Falls under simultaneous equation and measures LOCD	Falls under simultaneous equation and measures LOCD	1
25) 2010 OBJ. QUE. 25 If 2 tan x = 1.5, find $\cos x + 2 \sin x$	Falls under trigonometric equation and measures LOCD	Falls under trigonometric and measures LOCD	1
26) 2010 OBJ. QUE. 48. A wooden box 1cm thick is 15 cm long, 10 cm wide and 4 cm high. If the box is open at the top, calculate the volume of the wood used.	Falls under mensuration and measures LOCD	Falls under mensuration and measures LOCD	1

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27) 2010 OBJ. QUE. 46.			
A man took a loan of GC7200 at a simple interest rate from a cooperative society. He pays back GC8000 after 10 months. At what rate was the interest charged?	Falls under simple interest and measures LOCD	Falls under simple interest and measures LOCD	0
28) 2012 OBJ. QUE. 15 The angle of a sector of a circle of radius 6cm is 120^0. find the area of the sector in terms of π.	Falls under mensuration and measures LOCD	Falls mensuration and measures LOCD	1
29) 2012 OBJ. QUE. 44 A side and a diagonal of a rhombus are 10 cm and 12 cm, respectively, find the area.	Falls under mensuration and measures LOCD	Falls under mensuration and measures LOCD	1
30). 2013 OBJ. QUE. 29 Express 2-3log_{10}2 as the logarithm of a single number.	Falls under logarithm and measures LOCD	Falls under logarithm and measures LOCD	1

Source: Adapted from Glen (2016)