ANGLIA RUSKIN UNIVERSITY

INVESTIGATION INTO THE TEACHING AND LEARNING OF MATHEMATICS IN JUNIOR SECONDARY SCHOOLS: THE CASE OF GHANA

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ABSTRACT

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The 2007 revised mathematics curriculum in Ghana introduced many changes to the way mathematics should be taught and learned. However, before this research started in 2010, very little was known about how this subject is taught and learned. This study aims to investigate mathematics teachers' teaching practices and students' learning experiences in junior high schools (12-14 years) using a mixed methods design. The study's conceptual framework is informed by two different, but interrelated theories: behaviourism and constructivism.

Participants in the study were 24 mathematics teachers and 358 students from 12 schools. Semi-structured questionnaires were used to collect quantitative data about participants' perceptions, and classroom observations and interviews were used to collect qualitative data about actual classroom practices. The quantitative data was analysed using SPSS, STATSDIRECT and ORIGIN software and the qualitative data assessed using a thematic analysis approach.

The key findings include: teachers and students espoused the belief that their teaching and learning practices are consistent with the principles and guidelines of the new mathematics curriculum. Teachers perceived teaching practices were complex as they contain both behaviourist and constructivist beliefs; however, their actual teaching practices were didactic. It also emerged that both teachers and students try to avoid making mistakes, despite the importance of correcting students' misconceptions when promoting effective teaching and learning. The fact that peer influence is a key factor that shapes students' learning was an important theme that emerged from the interview and the classroom observations. Students were only willing to participate in class discussions if they knew the correct answer, as they would be ridiculed by their peers for giving a wrong answer.

The movement towards a more constructivist approach to teaching and learning, which is the prime objective of the new mathematics curriculum, occurred at a slower pace. Thus, a conceptual model for the teaching and learning of mathematics which advocates collaboration and partnership between teachers and students in the classroom is offered.

Key words: Teaching, Learning and Mathematics Curriculum

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART I: INTRODUCTION

Chapter 1

Introduction

1.1 Personal Reflections

This research study focuses on mathematics teachers' teaching practices and students' experiences of learning mathematics. The choice of this topic for my doctoral thesis has been informed by a number of factors. However, as argued by Bochner (1997), academic texts that "deny the personal voice and create an illusion of neutrality hurt the pursuit of truth" (p. 418). Throughout my years as a student, mathematics educator and researcher, issues relating to the teaching and learning of mathematics have been a main area of interest. My investigations into the teaching and learning of mathematics have been necessitated by my curiosity and personal experiences.

During my primary school education (6-12 years), I developed a keen interest in mathematics and this interest was inspired by my teachers who motivated me in class through a system of learning in which emphasis was placed on the learner rather than the teacher. However, my interest in the subject started to wane after my primary education because most of the classroom interactions were overwhelmingly teacher-centred and examination driven. Activities comprised 'rote learning' where we had to memorise formulas without understanding them and their applicability, which made the subject difficult and abstract. This experience echoes the findings of other researchers (e.g. Masingila 1993; Agudelo-Valderrama 1996; Eshun 2004; Eshun-Famiyeh 2005; Anamuah-Mensah and Mereku 2005) who claim that a greater proportion of students find mathematics difficult because of the way it is taught.

My interest in researching the teaching and learning of mathematics was further stimulated in 2002, when I was writing my undergraduate thesis. In this study, I investigated the kind of mathematical concepts which junior high school (12-14 year) graduates in various vocations (e.g. tailoring, dressmaking, carpentry and masonry) were using in their work places. The study aimed to examine the views of these graduates, exploring the relationship between the mathematical concepts they were applying at their respective work places and the mathematics they had learned in school. The results from the study were interesting and puzzling in the sense that the mathematical concepts the apprentices were presumed to be using at their respective work places were similar to those documented in the national curriculum (e.g. measurement, algebra and pattern formation). However, most of these graduate apprentices could not link the mathematical concepts they had learned at school to the methods they were using at their respective work places.

These puzzling results therefore inspired me to explore further to find out more about the teaching and learning of mathematics. During my years as a research assistant and mathematics educator at the Institute of Education (IoE) in Ghana, I had the opportunity to interact and engage in discussion with mathematics educators and students to explore their views regarding mathematics teaching and learning. The different views from the teachers and students concur with research recommendations on the need for change in the teaching and learning of the subject, as advocated in the literature (e.g. Ernest 2001; Boaler 2009; Willis 2010). Reflecting on these previous research recommendations and my personal experience, I became interested in the different views that teachers and students hold about the teaching and learning of the subject in the classroom. I have thus been reflecting on these issues and investigating how mathematics is taught and learned in Ghanaian schools has been informed by my personal experience, research recommendations and policy initiatives.

1.2 Background to the Study

Mathematics holds a key position in the curriculum and in virtually all countries it is a core component of the school programme of study (Keith 2000). It is also seen as a pivotal subject, both in its own right and because of its important connections with diverse fields such as the natural sciences, engineering, medicine and the social sciences (Keith, 2000). However, for the past three decades there has been growing concern about falling standards of students' achievements in mathematics at both national and international levels (Blum 2002; Törner and Sriraman 2006).

How students experience mathematics in schools, as well as students' poor performance in mathematics over the years, has therefore become a major concern in almost every part of the world. For example, there is a common understanding in the United Kingdom and North America that students of all ages experience a wide range of difficulties when attempting to study mathematics (Masingila 1993; Ball *et al.* 2001; Baker 2008). Masingila (1993) argues that most students construct mathematical knowledge through the learning of procedures and formulae rather than comprehending the meaning of these procedures and therefore find it difficult to apply this knowledge outside the classroom. Similarly, Baker (2008) adds that, most students are not able to conceptualise and apply the mathematical skills they learnt at school when solving day to day problems.

In Ghana, research by Eshun (2004) and Eshun-Famiyeh (2005) has also shown that mathematics continues to be the most difficult subject in the school curriculum; this general perception is reflected in students' performance over the years. For example, a Criterion Reference Test (CRT) conducted in 1996 and 2000 established that only 1.8% and 4.4% of primary year six students nationwide obtained a mark of 55% respectively (MoE 2002).

Furthermore, the results from the Trends in International Mathematics and Science Study (TIMMS) conducted for junior secondary year two (grade 8) students in 2003 portrayed a generally poor performance on the part of Ghanaian students, with students' scoring an average of 276 in mathematics, which was significantly lower than the international average of 467 (UEW/GES, 2003). These results are a clear manifestation of students' negative perception of mathematics and a reflection of the status of mathematics teaching and learning in the country.

Improving the teaching and learning of mathematics has therefore become an issue of considerable concern over the past three decades in almost every part of the world. These demands have led to restructuring and the introduction of a new school curriculum and teaching methods. The evolution of these new school curricula and methods is designed to find ways to empower students to use practical and investigative approaches when learning mathematics; these approaches have been the new trend in the field for some time now (Thomasenia 2000). Chambers (2008) opines that students' difficulties in learning mathematics and the low achievement in mathematics among most students in England over the years led to the introduction of the national curriculum in the United Kingdom in the 1980's. He further adds that the national curriculum was intended to provide a level platform for all students. In addition, the national numeracy strategy and the daily mathematics lessons in schools are also means of motivating students to develop an interest in mathematics (Chambers 2008).

Mosvold (2005) reports that the need to improve the standards of mathematics education in Norway and make connections with school mathematics and everyday life through active construction of knowledge by pupils led to the introduction of a new mathematics curriculum in 1997. Mosvold further adds that the 1997 curriculum was based on the idea that the teaching and learning of mathematics should be directed by the national curriculum, with the prime objective of increasing connections with real-life situations (mathematics in everyday life). Jita (2002) reveals that the South African government has launched numerous initiatives to improve the teaching and learning of mathematics, with the aim of exposing students to more experiential learning and learner-centred approaches.

In Ghana, the government and other stakeholders in the education sector have introduced a number of initiatives to promote effective teaching and learning of mathematics with the aim of making the subject more enjoyable (Anku 2008). For example, in 2003 the Ministry of Education (MoE), in collaboration with the Teacher Education Division (TED), reviewed the teacher education curriculum and upgraded all Initial Teacher Training Colleges (ITTC's) to diploma awarding institutions with the aim of improving teachers' knowledge of content and pedagogical skills in the various subject areas. In addition, the Ministry of Education, in collaboration with other international agencies such as the Japan International Cooperation Agency (JICA), the United States Agency for International Development (USAID) and the Department for International Development (DFID), have shown enormous commitment by embarking on mathematics and science projects to improve the teaching and learning of mathematics and science at the basic, secondary, teacher training and tertiary levels (Ampiah *et al.* 2000).

The latest of these initiatives was the introduction of a new mathematics curriculum in September 2007, which showed a paradigm shift in the teaching and learning of mathematics and other school curriculum subjects in the country. Although there is no consensus as to what constitutes good mathematics teaching and learning practices in Ghana, the 2007 curriculum offers new ideas and directions based on the principles of constructivism. The main rationale for the introduction of the new curriculum was to enable all young Ghanaians to acquire a conceptual understanding of mathematics, mathematical skills, insights and attitudes and adhere to values that will contribute successfully to their chosen careers and daily lives (MoESS 2007).

In general, the new syllabus is based on the twin premises that all pupils can learn mathematics and that all need to learn mathematics. To achieve this, the syllabus has been designed to promote co-operative learning among students and the use of student-centred teaching approaches (MoESS 2007). These new policy initiatives in Ghana reflect research recommendations and theoretical shifts and changes in the teaching and learning strategies for mathematics at the international level (Potari and Georgiadon-Kabouridis 2009).

1.3 The Gap in Knowledge

In Ghana, how mathematics is taught and learned and the issue of improving the teaching and learning of the subject has been the object of national scrutiny for some time now. In response to this demand, researchers, educators and other stake holders in the education sectors have conducted empirical research into the issue and the way forward (e.g. Agyeman 1993; Kraft 1994; Asiedu-Addo and Yidana 2004; Mereku 2003). Based on these empirical research and recommendations, the new mathematics curriculum was introduced in 2007.

However, when this present study began in 2010, three years after the introduction of the new mathematics curriculum, no study had specifically investigated how the subject is taught and students' experiences of learning mathematics in relation to the curriculum recommendations. Moreover, relatively few studies have explored the teaching and learning of mathematics using the different data collection and analysis procedures used in this study within the Ghanaian context. Also, although a number of researchers (e.g. Mereku 2003; Eshun 2004; Eshun-Famiyeh 2005) have explored mathematics classroom practices at the primary and senior secondary levels, very little is known about teaching and learning of mathematics at the junior secondary level, which is the transition point from primary to senior secondary schools.

1.4 Purpose of the Research

The purpose of this study is therefore to explore how mathematics is taught and learned in Ghanaian Junior High Schools (JHS). Specifically, the research seeks to understand how mathematics teachers instruct mathematics by examining their teaching methods and why they use this pedagogy. Furthermore, the study sought to understand students' experiences of learning mathematics. The study also aims to provide insights for the purpose of informing policy and practice and make possible contributions to the field of mathematics teaching and learning. The present study is guided by the overall research question: How is mathematics taught and learned in Ghanaian Junior High Schools (JHS)? Related research questions are:

1. What teaching methods are used by mathematics teachers?
2. Why do mathematics teachers use these teaching methods?
3. Is there any relationship between teachers' perception of their classroom practices and what they actually do in class?
4. What are students' perceptions of their teachers' teaching practices?
5. What are students' experiences of being taught mathematics?

To find answers to these research questions, it was necessary to adopt a research design that would help to provide different, but interrelated results from different sources to attain a holistic picture of the problem under consideration. In order to achieve this, the present study employs a mixed methods design by utilising both quantitative and qualitative data collection and analysis procedures. The quantitative part of the study seeks to measure teachers' and students' perception of classroom practices through the use of semi-structured questionnaires. The qualitative part aims to explore teachers' actual teaching practices and students' experiences using semi-structured observations and interviews. The research design and methodology used in this study is discussed further in the methodology chapter (Chapter 6).

1.5 Significance of the Study

International and national assessments of Ghanaian students have illuminated their poor academic achievement in mathematics. It is for this reason that empirical evidence regarding the issue of mathematics teaching and learning has become a major concern for all stakeholders in the country. It is essential to determine the perceptions held by teachers and students regarding their teaching and learning practices and what they actually do in their respective classrooms. By gaining an insight into these perceptions and actual teaching and learning practices, this study expects to contribute to knowledge in the following ways: Firstly, the findings and conclusions from this study will improve the current situation by providing evidence for debate with regard to how mathematics is taught and learned in schools. This, in turn, may provide valuable insights into how future curriculum restructuring, teacher training and development may better serve the needs and aspirations of the people.

Moreover, the data gleaned from this study may provide information about the challenges posed by the new mathematics curriculum and the possible ways forward. In turn, this may contribute to the existing body of literature and also help towards building a theory of mathematics teaching and learning within the Ghanaian context. In this study, the classroom context is considered to be complex in nature and particular emphasis is given to understanding how the subject is taught and learnt from multiple perspectives. Methodologically, the use of the mixed methods design in the present study has the potential to extend our understanding of how mathematics is taught and learned in our schools by providing both quantitative and qualitative data about the situation. The use of a mixed methods design enables access to different kinds of empirical evidence which cannot be achieved by using a single approach.

1.6 Structure of the Thesis

This thesis is divided into five parts. The first part is the introduction and includes Chapter 1 and 2. Chapter one, the *Introduction*, presents the rationale for the study and explains how my personal experiences as a student, educator and researcher have informed my choice of this topic. The research problem and its importance; the purpose of the study and the potential contributions which could be made by the study to the field are also outlined in this chapter. Chapter 2, *Ghana- The context for the research*, discusses Ghana's education system with particular reference to its historical overview; its structure; challenges and initiatives taken to improve teaching and learning and issues relating to mathematics education in Ghana. The chapter also presents a review of the junior high school mathematics curriculum and the training of junior high school mathematics teachers in Ghana.

The second part of this thesis presents the theoretical perspectives of the study and includes Chapter 3, 4 and 5. Chapter 3, *Behaviourism and Mathematics Teaching and Learning*, illustrates a behaviourist view regarding the nature of mathematics teaching and learning. This chapter examines the various teaching and learning practices associated with behaviourism and how they impact on the teaching-learning process. The teaching strategies discussed in this chapter represent teacher-centred approaches in which the teacher transmits information to students and students passively construct knowledge by memorising the information given by the teacher. The chapter also discusses the advantages and drawbacks associated with behaviourism.

Chapter 4, *Constructivism and Mathematics Teaching and Learning*, examines a constructivist view regarding mathematics teaching and learning; teaching and learning practices associated with constructivism and how this impacts on the teaching-learning process. The teaching strategies discussed represent a student-centred approach where students construct knowledge through active participation in the teaching-learning process. Chapter 5, *Empirical Research*, discusses the current trends in the teaching and learning of mathematics and argues that the national call for change in mathematics teaching and learning has become necessary due to the introduction of pedagogical practices underpinned by constructivism in mathematics classrooms. In this chapter, the principles of behaviourism and constructivism and issues from the empirical research findings are brought together and it is proposed that no single theoretical perspective is sufficient for analysing mathematics teaching and learning. Based on this proposition, a conceptual framework of the study is presented and it is argued that the teaching and learning of mathematics goes beyond the ideas of behaviourism and constructivism and that the conceptual framework for this research integrates ideas from these two different, but interrelated, theoretical perspectives.

Part three explains the research methodology and includes Chapter 6. In this chapter, *Research Methodology*, the choice and justification for the research design of the study, research instruments, the data collection and analysis procedures, the ethical considerations and the quality of the research process are discussed. Part four presents the study results and analysis and includes Chapter 7, 8 and 9. Chapter 7, *Results, Findings and Analysis of Questionnaire Data*, presents the findings regarding teachers' and students' perceptions of their teaching and learning practices. Chapter 8, *Individual Case Analysis*, reveals the results and findings from each individual case study by separately corroborating the results and findings from the questionnaire, classroom observation and interview and synthesising the data from these three data sources to present a holistic view of each case.

Chapter 9, *Cross-Case Analysis*, examines cross-case results and findings to identify patterns of similarities and differences across the emerging themes of the study and finds answers to the research questions raised. Part five, which comprises Chapter 10, *Summary and Conclusions*, summarises the research findings and how the research questions have been answered. In addition, the study's contribution to new knowledge at both the national (Ghanaian context) and international levels is explained. The chapter also discusses the implications of the findings for further research.

1.7 Summary

This chapter has explained the background of the study, the research context and the personal motivation that led to the origin of this study. Furthermore, it has offered a rationale for the study by identifying gaps in knowledge, has revealed the significance of the study and presented the research questions guiding the study. The next chapter will provide an overview of Ghana's education system and the junior secondary mathematics curriculum in Ghana to contextualise the study and also inform readers who may be unfamiliar with education policy and practice in Ghana.

Chapter 2

The Context of the Study: Ghana

2.1 Introduction

This chapter outlines the education system in Ghana in order to illuminate the context of the research study. The chapter describes the development of education in Ghana and the characteristics of Ghana's education system and has three sections, beginning with Ghana's profile, with particular reference to the country's location, people and language. Secondly, a brief overview of Ghana's education system with reference to the development of education in the country is presented. Thirdly, in line with the purpose of the study, the last section of this chapter is devoted to the Junior High School (JHS) education system, with particular reference to the development of the basic school (6-14 years) mathematics curriculum.

2.2 Ghana: Geographical Background and People

Figure 2. 1: Map of Ghana

Source: Rand McNally New Millennium World Atlas

Ghana is a West African English speaking republic and one of the most populous countries in Sub-Saharan Africa, with a current population of approximately 22.4 million with a growth rate of 3.0% (NPC 2007). The 0-14 year old dependency rate is 84% and 44% of the population are under 15 years old. About 36% of the people live in urban areas; two-thirds are primarily dependent on agriculture for their livelihoods and income (Akyeampong *et al.* 2000).

The country covers an area of approximately 238,540 km^2 and it is bordered to the north and northwest by Burkina Faso, to the east by Togo, to the south by the Gulf of Guinea, and to the west by Côte d'Ivoire (Akyeampong *et al.* 2000). Ghana gained independence from Britain on March 6, 1957 and thus became the first independent majority-ruled nation in Sub-Saharan Africa (Akyeampong *et al.* 2000). The country is divided into ten administrative regions and each region is separated into a number of metropolis and districts. At present, there are 170 metropolitan, municipal and district assemblies in the country and 67% of the population live in rural areas (Agbeko 2007). Ghana's major ethnic groups are: Akan (49.1%), Mole Dagbon (16.5%), Ewe (12.7%) and the Ga-Dagme (8.0%), but this classification is only generic to cover a broader spectrum of ethnic groups (Ampiah and Akyeampong 2002, p.1). There are over 100 different dialects and, of these, eleven (Twi, Ga, Ewe, Nzema, Gonja, Walewale, Kasem, Fantse, Dagaare, Gonja, Dagbane) are recognised and used in schools as a medium of instruction from year 1 to 4. From year 5 through to university, the official language of instruction is English (Ampiah and Akyeampong 2002).

2.3 Development of Education in Ghana

The history of state-organised education in Ghana can be traced back to the early 14th century when European merchants established castle schools (Antwi 1991a; Davis and Ampiah 2005). The development of education in Ghana can be classified under both the pre-independence period and post-independence period.

The Pre-Independence Period

The Danes were the first European merchants to travel to Ghana and they established the castle schools exclusively to teach and train the children (mulattoes) that the colonial masters had with African women (Graham 1971). During this period, the education system emphasised reading, writing arithmetic and vocational education. Prior to 1874, when the British government had full authority over the country, African boys and girls had little or no access to primary education and education in general (Graham 1971). However, prior to the establishment of castle schools, it is believed that informal education was being practiced in the local communities. This form of informal education was used by parents and family elders as a means of teaching the younger generation morals to inculcate good character and good health into these youthful members of the community.

The introduction of formal education for Ghanaian boys and girls began in the 1820s; between 1821 and 1881 the British government funded the establishment of new schools to train African boys and girls and by 1881 139 schools existed across the country (Graham 1971). Another feature of the educational process in Ghana, during the colonial period was the sending of African boys to Europe for education; most of these boys were the sons of the local chiefs and prominent people in the locality. The rationale for sending the sons of the chiefs to Europe to study was to ensure that the chiefs and the local people in the country would value the friendship and, to a greater extent, adopt the views of the British government (Graham 1971, p.6). The establishment of these schools led to an increase in student enrolment across the country; thus, one of the major problems associated with the establishment of the schools was a shortage of teachers. Due to this, the government initiated a plan for the establishment of teacher training colleges in every province of the country.

The British government's commitment to educating African children led to the introduction of an education development plan in the late 1880s. The main aim of this education development plan was to improve teaching and learning in the country; the plan was therefore aimed at training teachers to handle the ever growing number of schools throughout the country (Antwi 1991a). In general, the plan also aimed to provide primary education for all African boys and girls, better salaries for teachers and the establishment of a royal college to offer general secondary education (Antwi 1991a). The nineteenth century, therefore, witnessed major developments in Ghana's education system with the establishment of new schools and training of teachers. Nevertheless, this progress and development was affected by the First and Second World Wars, which led to the collapse of most of the schools and teacher training colleges.

The Post-Independence Period

The latter part of the 1950s was the period in which most African countries gained independence and when Ghana attained independence in 1957, the search for new educational systems and policies began. The search led to the establishment of education acts and education development plans. For example, a Five-Year Development Plan dubbed education for accelerated development that aimed to develop the socio-economic base of the country through educating the citizenry was initiated 1961. The recommendations for the development plan paved the way for the restructuring of Ghana's education system and this led to the introduction of a number of educational reforms (Graham 1971).

The first Education Act was initiated in 1962 by the first president of the country with the aim of achieving free compulsory universal primary education for all Ghanaians. The free universal compulsory Education Act led to the establishment of new schools throughout the country and student enrolment increased considerably in the early 1960s and late 70s (Mfum-Mensah 1998). However, the education system became dysfunctional in the early 1980s due to frequent changes in government and a civil war which led to the institution of different educational reforms and the abandonment of previous and existing reforms (Mfum-Mensah, 1998).

The most ambitious and prominent educational reform that brought about many significant changes in Ghana's educational system took place in 1987 (Osei, 2006). This educational reform led to the adoption of an educational system which provided six years of primary education, commencing at the age of six years old, three years of junior secondary education, three years of senior secondary and an average of four years of tertiary education (Akyeampong and Furlong, 2000). The traditional route from primary school through to university, which was phased out in 1987, was a maximum of ten years of primary school with the option of taking the highly competitive Common Entrance Examination between the 6th and 10th year.

In the mid 1990's, various public concerns were raised about the quality of education in the country, especially at the pre-tertiary level. As a result of these concerns, the government at the time introduced the Free Compulsory Universal Basic Education (FCUBE) programme in 1995. This was a package of reforms designed specifically to focus on basic education access and quality (MoE 1994). The Free Compulsory Universal Basic Education programme brought many changes to the school curriculum, coupled with the aim of improving teacher development and increasing access to basic education. The programme had three primary goals:

- Improving the quality of teaching and learning with more emphasis on teacher training and development, improving teacher motivation through incentive programmes;
- Improving efficiency in management with activities focusing on the reorganisation and re-orientation of management practices in the education delivery system; and,
- Increasing access and participation. The activities developed to increase access and participation included expanding infrastructure facilities and services to enhance access and addressing issues of enrolment and retention for all school-age children (MoE 1994).

Despite the achievement of the 1995 reforms in enhancing access, the issue of inadequate facilities and improving the quality of teaching and learning was not wholly addressed and in 2003 the government embarked on another educational reform with the aim of increasing access to education, and making the education system of the country more relevant to the socioeconomic status of the country and more competitive to meet international standards. This led to the introduction of a new educational reform in the year 2005/2006. The new reform was officially introduced in September 2007 and specified two years of kindergarten education, six years of primary school, three years of junior high school, four years of senior high school and four years of university education.

The 2007 educational reforms were intended to allow sixty percent of Ghanaian students to pursue science related courses and forty percent humanities and also provide an improved syllabus (MOESS, 2007). To achieve these targets, new school buildings were built and teaching and learning materials provided, as well as workshops and training programmes being organised so teachers could stay abreast of the new curriculum. The unique feature of the 2007 education reforms is the inclusion of kindergarten education into the formal education system and the use of both Ghanaian languages and English as the medium of instruction from kindergarten and lower primary. Moreover, the new reform emphasised literacy, numeracy, creative arts and problem solving skills at the basic level (6-15 years) to promote conceptual understanding and application of concepts to real life (MOESS, 2007). Figure 2.2 shows the structure of the new school system.

Years	Age	TERTIARY EDUCATION	University/Polytechnic/Professional Institutes/College of Education/Teacher Education.
4	18 – 19	SECOND CYCLE EDUCATION	SENIOR HIGH SCHOOL (Grade 10- 13)
3	17 – 18		
2	16 – 17		
1	15 – 16		
3	14 – 15		JUNIOR HIGH SCHOOL (Grade 7 – 9)
2	13 – 14		
1	12 – 13		
6	11 – 12	FIRST CYCLE EDUCATION	PRIMARY EDUCATION (Basic literacy, Numeracy, Science and Social Studies)
5	10 – 11		
4	9 – 10		
3	8 – 9		
2	7 – 8		
1	6 – 7		
2	5 – 6		KINDERGARTEN
1	4 – 5		

Figure 2. 2: The Structure of Ghana's School System - 2007

2.4 Initiatives to Improve the Quality of Education in Ghana

In order to improve the quality of teaching and learning in Ghanaian schools, the Government of Ghana, in collaboration with other stakeholders in the education sector, has taken some initiatives over the past couple of decades. Firstly, as discussed above, in 1995 the Ghanaian Government introduced the Free Compulsory Universal Basic Education programme which was intended to increase access and equity in education. In terms of access, it can be said that enrolment at both the primary and secondary school levels has been increasing at a rapid rate. However, despite these achievements, Palmer (2005) argues that there are more than one million children of primary school-age not enrolled at the primary level and the situation at the secondary level is very alarming.

Furthermore, as a way of solving the problem of poor quality of teachers, the Ministry of Education, in collaboration with the Teacher Education Division, reviewed the teacher education curriculum in 2003. The purpose of the review was to upgrade all Initial Teacher Training Colleges (ITTC's) to diploma awarding institutions with the aim of improving teachers' content knowledge and pedagogical skills in the various subject areas. The Institute of Education (IoE), University of Cape Coast, which is responsible for basic school (grade 1 - 9) teachers' certification in Ghana, had launched a number of initiatives to train teachers in diploma and post-diploma degrees in basic education through their programme of evening classes for teachers. The Centre for Continuing Education (CCE) of the University of Cape Coast (UCC) and the University of Education (UEW) also run different distance education programmes for teachers as a way of helping them to develop themselves to meet new challenges. Student-teachers in these programmes specialise in different subject areas including mathematics, science, English, home economics and social studies, with mathematics and science as the fundamental subjects.

Improving the quality of education in Ghana with an emphasis on science, technology and mathematics has been the paramount aim of the present government and the 2007 educational reform policies are geared towards making science, technology and mathematics the backbone of the country's development. The Government of Ghana, in collaboration with the Ghana Education Service, Ministry of Education, Teacher Education Division and other international agencies such as the Japan International Cooperation Agency, United States Agency for International Development and the Department for International Development, have shown enormous commitment by embarking on mathematics and science projects to improve the teaching and learning of these subjects to raise students' achievements (Akyeampong and Kuroda, 2007).

Furthermore, the Government of Ghana, in collaboration with the Japan International Cooperation Agency, introduced the science, technology and mathematics clinic project as a way of motivating more students (especially girls) to develop interest in these subjects (Ampiah *et al.* 2000). The Ministry of Education in Ghana and its collaborating agencies have intensified their efforts and resources to provide and promote innovative strategies in teaching and learning, with much emphasis on mathematics. However, the impacts on students' achievements in both international and national examinations are still far from satisfactory (MoE 2002, Ansu-Kyereme *et al.* 2002, Akyeampong and Kuroda 2007, Anku 2008). According to Akyeampong and Kuroda (2007) the situation calls for a revamp of mathematics education, with more emphasis on the creation of methods which can improve the teaching and learning of mathematics through problem solving in which students play an active role. However, it is important to understand how the subject is taught and learned at present before the adaptation of a particular method, and this is what this present study seeks to establish.

2.5 The Characteristics of Ghana's Secondary Education System

The restructuring and introduction of new educational reforms since independence have led to major changes at all levels of Ghana's education system. However, for the purpose of this study, the focus will be on the changes that have occurred at the Junior Secondary level with an emphasis on the new junior high school mathematics curriculum, because this is the area of interest of the present study. Before the 1987 reforms, the secondary school system comprised five years of middle school and two years of sixth form education leading to the Advanced Level Certificate (Akyeampong and Furlong 2000). The school curriculum was composed of core courses such as mathematics, English language, general science and bible knowledge, which must be passed in order to gain the ordinary level certificate. After this, students had to specialise in any of the academic disciplines: sciences, general arts, religious studies, business studies and vocational studies at the advanced level.

After the 1987 reforms the structure of the secondary school system was divided into two phases: junior high school (JHS) education (three years) which are free and compulsory and senior secondary school (SSS) education (another three years). The junior high school curriculum had 13 core subjects except French, which was optional and could be studied only if there was a qualified member of staff. The subjects included: mathematics, integrated science, social studies, cultural studies, Ghanaian languages, English language, French (optional), agriculture, life skills, physical education, technical drawing, basic technical skills, and vocational skills (Akyeampong and Furlong, 2000).

The introduction of the 2007 educational reforms brought about a considerable number of changes in the school system, especially at the secondary level, with three years of junior high school (JHS) and four years of senior high school (SHS) education. The government's intention behind increasing the duration of senior secondary education to four years was to ensure students are adequately prepared for tertiary education and job placements. The present junior high school curriculum has eight subjects: mathematics, integrated science, social studies, Ghanaian languages, English language, French (optional), physical education and information and communication technology (ICT). Junior high school graduates have to sit the Basic Education Certificate Examinations (BECE) in their final year (year 9) and are required to obtain an aggregate of 6-36 in six subjects to be admitted into senior high schools. Moreover, students also have the opportunity to enter one of the vocational institutions in the country or begin to work.

2.6 The New Mathematics Curriculum for Junior High Schools

The teaching and learning of mathematics in Ghanaian schools, as in most other countries, is prescribed by the national curriculum which provides equal educational opportunities for all students (Nabie and Kolorah-Ekpale 2004; Kuwayama *et al.* 2007). The history and development of the mathematics curriculum can be traced back to the establishment of castle schools in the colonial era (Kuwayama *et al.* 2007). A new programme, Mathematics for Primary Schools, was introduced in Ghana in 1972 in order to make learning mathematics more interesting and meaningful to Ghanaian children (Mereku 2003; Kuwayama *et al.* 2007).

Since the introduction of this first national mathematics curriculum in Ghana in 1972, a number of new mathematics curricula have been developed, all with the aim of improving the teaching and learning of the subject. The 1987 mathematics curriculum was based on the guidelines of the 1987 educational reforms aimed at helping pupils see mathematics as a unified body of knowledge and not as a collection of isolated topics. The 1987 curriculum was based on the premise of helping pupils to develop a mathematical outlook by providing the opportunity for them to understand the world around them in mathematical terms, to express their ideas in mathematical language, to develop the ability to give clear and correct explanations and to make classifications and generalisations (Davis and Ampiah 2005).

In the early 1990s, the government embarked on another educational reform which was implemented across the country in 1995. The 1995 mathematics curriculum replaced the 1987 curriculum and was in use in the country until 2007; it was designed with the aim of making Ghanaian students competitive at the national and international level. To achieve this, the prime objective of the curriculum was to help students to develop an interest in mathematics and be active participants in the teaching-learning process (Mereku 2003). However, despite the numerous changes made to the mathematics curriculum since the introduction of the first curriculum, students' achievements and results were still not at a desirable level. For example, the Ministry of Education (2002) reported students' performance in mathematics over the years gives an indication that the acquisition of basic mathematical concepts emphasised in these curricula has not materialised.

In response to these concerns and demands, in January 2002 the Government of Ghana set up a presidential committee to review educational reforms in Ghana. The committee published its report in October 2002, and emphasised the need and ability to make use of recent developments in science and technology, especially information and community technology (ICT) to enhance teaching and learning. Based on this, the current mathematics curriculum was announced in October 2002 and was implemented in September 2007 as part of the new educational reform, with the view to improving the quality of instruction and increasing its flexibility to accommodate diverse student abilities (MOESS 2007).

The new mathematics curriculum for Ghanaian Junior High schools (JHS) is a sixty-six page document which outlines the rationale behind the teaching and learning of mathematics. The curriculum is based on the twin premises that all can learn mathematics and that all need to learn mathematics with a view to achieving a curriculum that reflects individual students' needs. The ultimate goal of the current curriculum is to enable all students to acquire the mathematical skills, insight, attitudes and values needed to be successful in their chosen careers and daily lives by increasing the students' self-oriented learning abilities to the maximum.

Key Characteristics of the New Mathematics Curriculum

The aims of the current mathematics curriculum follow the premise that "strong mathematical competencies developed at the JHS level are necessary requirements for effective study in mathematics, science, commerce, industry and a variety of other professions" (MOESS, 2007; p. ii). The current curriculum focuses on the student and is designed to help the learner:

- develop the skills to select and apply criteria for classification and generalisation
- communicate effectively using mathematical terms, symbols and explanations through logical reasoning
- use mathematics in daily life by recognising and applying appropriate mathematical problem-solving strategies
- understand the process of measurement and acquire skills in using appropriate measuring instruments
- develop the ability and willingness to perform investigations using various mathematical ideas and operations
- work co-operatively with other students to carry out activities and projects in mathematics and consequently develop the values of cooperation, tolerance and diligence
- use the calculator and the computer for problem solving and investigation of real life situations

- develop an interest in studying mathematics at a higher level in preparation for professions and careers in science, technology, commerce and a variety of work areas

The current curriculum is composed of five major areas supported by skills, understanding and attitudes which students need in order to make an informed judgement and apply this knowledge to solve real life problems. The five major areas comprise: *numbers and investigation with numbers*; *geometry*, *estimation and measurement*; *algebra; statistics and probability*. Numbers covers the reading and writing of numerals in different number bases and the application of the four basic operations: ratio, proportion, percentages, fractions, integers and rational numbers related problems. Investigation with numbers should provide students with the opportunity to discover number patterns and relationships, and to use basic arithmetic operations meaningfully.

Geometry covers the properties of solids, planes and shapes, as well as the relationship between them, whilst estimation and measurement include practical activities to estimate and measure length, area, mass, capacity, volume, angles, time and money. Algebra, which forms the integral part of the curriculum, covers algebraic expressions, relations and functions. The last component of the curriculum, statistics and probability, involves the collection, organisation, representation and interpretation of data and an understanding of the fundamental concept of probability and its application in real life situations (MOESS 2007, p.3-4). These five areas are further divided into 39 units, of which JHS1 has 15 units, JHS2 has 16 units and JHS3 has 8 units. The organisation of the junior high school mathematics curriculum is presented below.

Table 2. 1: Organisation of the Junior High School Mathematics Curriculum

Units	JHS1	JHS2	JHS3
Unit 1	Numbers and Numerals	Numeration Systems	Application of Sets
Unit 2	Sets	Linear Equations and Inequalities	Rigid Motion
Unit 3	Fractions	Angles	Enlargements and Similarities
Unit 4	Shape and Space	Collecting and Handling Data	Handling Data and Probability
Unit 5	Length and Area	Rational Numbers	Money and Taxes
Unit 6	Powers of Natural Numbers	Shape and Space	Algebraic Expressions
Unit 7	Introduction to the Use of Calculators	Geometric Constructions	Properties of Polygons
Unit 8	Relations	Algebraic expressions	Investigations with Numbers
Unit 9	Algebraic Expressions	Number Plane	-
Unit 10	Capacity, Mass, Time and Money	Properties of Quadrilaterals	-
Unit 11	Integers	Ratio and Proportion	-
Unit 12	Geometric Constructions	Mapping	-
Unit 13	Decimal Fractions	Area and Volume	-
Unit 14	Percentages	Rates	-
Unit 15	Collecting and Handling Data (Discrete)	Probability	-
Unit 16	-	Vectors	-

Table 2.1 outlines the contents to be covered in each year; however, it does not tell the teacher which or how many topics should be covered each term, but instead encourages teachers to ensure that students progressively acquire a good understanding and application of the material specified for each year's class work (MOESS 2007).

Differences between the Old and the New Mathematics Curriculum

An analysis of mathematics teaching and learning at the junior secondary level before the introduction of the new curriculum shows that classroom practices were characterised by teacher-centred approaches to teaching (Mereku 2003; Fletcher 2005). The old curriculum, which was used until 2007, emphasised the use of discovery teaching methods and other student-centred approaches. However, only a few teaching/learning activities that would encourage student-centred teaching were included in the curriculum (Mereku 2003). The old curriculum was designed with much greater emphasis on academic attainment of students, with little or no emphasis on the utilitarian effect of mathematical concepts. One of the reasons for students' inability to appreciate and apply the mathematics they learn is the fact that most students do not understand the utilitarian effect of these concepts (Boaler 2009).

Unlike the old curriculum, the new mathematics curriculum was designed to enable all Ghanaian young people to acquire the mathematical skills, insights, attitudes and values that they will need to be successful in their chosen careers and daily lives (MoESS 2007). The new curriculum therefore encourages the acquisition of more skills and varied teaching methods and resources to help students to develop the mathematical skills that they will need in their daily activities (MoESS 2007). A shift from a teacher-centred approach to a more participatory teaching method has also occurred, with time spent on comprehension, application and experimentation, as indicated in the content of the mathematics curriculum. The new national mathematics curriculum therefore highlights students playing an active role in the teaching-learning process, which represents a shift from a teacher-centred approach to teaching to a student-centred approach.

Teaching Methods Proposed under the New Mathematics Curriculum

As highlighted above, the new curriculum is underpinned by the epistemologies of constructivism and it advocates for a change in teachers' role as custodian of knowledge to facilitators in the teaching-learning process. The current curriculum requires the teacher to:

- create learning situations and provide guided opportunities for students to acquire as much knowledge and understanding as possible through their own activities
- emphasise student-centred activities and communication
- foster interest and self-confidence in the learning of mathematics by providing students with opportunities to explore various mathematical situations in their environment to enable them make their own observations and discoveries
- apply various instructional practices to cater for individual students' needs
- utilise concrete manipulatives to help students to compare, classify, analyse, look for patterns and spot relationships and draw their own conclusions
- consider students' evaluation as an integral part of the teaching learning process and evaluation exercises should challenge students to apply their knowledge to issues and problems and engage them in developing solutions and increasing investigative skills

The teaching methods envisioned in the new curriculum and the teacher's guide include a group work method, discovery method, investigative method and demonstration method. In general, the new mathematics curriculum encourages teachers to use student-centred approaches in their teaching by avoiding rote learning and drill-oriented methods in order to achieve optimum student learning. The current curriculum also encourages teachers to emphasise the cognitive, affective and psychomotor domains in their instructional system to help students acquire the capacity for analytical thinking and the ability to apply their knowledge to problems and real life situations.

The guidelines outlined in the new curriculum suggest that students' active participation in the teaching and learning process should be considered first by the teacher in his/her choice of any particular teaching method or activities for a particular topic. According to the general aims of the new mathematics curriculum, students are encouraged to work collaboratively in small groups to develop new knowledge and different ways of solving problems. The new guidelines suggest a constructivist epistemology where the individual learner is given the opportunity to develop and construct their own knowledge through interactions with their environment.

Assessment Procedures in the New Curriculum

Assessing students' understanding and acquisition of knowledge forms an integral part of the new mathematics curriculum and different methods of assessing students are used by teachers. However, the national curriculum outlines two forms of assessment at the junior high school level: School Based Assessment and External Assessment. School Based Assessment, which is a form of internal assessment, comprises class tests, homework, class exercises and end of term examinations. It forms 30 percent of the individual student's score. At the end of the third year, students have to sit for the Basic Education Certificate Examination and this forms 70 percent of the student's total score. The scores from both the internal and external assessments are used for selection into the senior high schools, technical and vocational institutions (MOESS 2007).

Despite the innovative changes in the current mathematics curriculum, which reflect the prime aim of changing the teaching and learning of mathematics from teacher-centred to a student-centred approach, the objectives spelt out above do not fully match the epistemology of constructivism. The skills and competencies outlined in the new curriculum still encourage teachers to show, demonstrate and explain things to students and do not differ greatly from the old mathematics curriculum. The current mathematics curriculum therefore only limits the teacher's effect on the teaching and learning process, which suggests that the teacher ought to be an active participant rather than a mere facilitator in the classroom. In addition, the majority of the teaching and learning activities outlined in the new curriculum do not differ from those in the old curriculum. Most of these teaching and learning activities fail to make links and use real life situations to demonstrate the numerous mathematical concepts and skills included.

2.7 Training of Junior High School Mathematics Teachers

The history of teacher education in Ghana can be traced back to 1848, when the Basel Mission opened the first teacher training college, the Presbyterian Teacher Training College (PTC) at Akropong-Akwapim in the eastern region of Ghana. Following independence in 1957 and a strong government commitment to developing human resources, more teacher training colleges were opened to cater for the increased demand for teachers due to the expansion in schools and enrolment rates (Akyeampong 2003). Presently, there are 42 teacher-training colleges offering courses leading to the award of a diploma certificate in teaching; four are private and the rest are public training colleges. There are seven female colleges, one male technical teacher training college and the remainder are co-educational colleges.

The initial emphasis of the 1987 and 1995 educational reform was to increase access and improve educational inputs (Akyeampong 2003). Prior to this, the development and training of teachers in Ghana was often based on ad-hoc programmes to meet emergency situations and the needs of the education system. For example, the establishment of the first teacher training college was intended to solve an emergency problem of a shortage of teachers in the country due to the growing number of schools and student enrolments (Akyeampong and Furlong 2000).

The training of teachers in the early and mid 90's was organised at two levels: the post-middle (or junior-secondary) level and the post senior-secondary level; both programmes led to an equivalent qualification '*Teacher's Certificate A'*. The post-middle programme was a four year teacher training programme which was established in 1930 to train teachers to teach at the primary and junior-secondary schools (Akyeampong and Furlong 2000). Further to the expansion of the education system and the increasing demand for more teachers, a two-year post secondary teacher training programme was introduced in 1937 to train teachers for senior-secondary schools. These two levels of training were phased out in 1991 and replaced by a three-year post-secondary teacher training programme, which is run by all the teacher training colleges in the country (Akyeampong 2003).

The teacher training curriculum fluctuates and the preparation of syllabi for the teacher training colleges takes place on subject panels formed by the Teacher Education Directorate with representation from the Curriculum Research and Development Division (CRDD) of the Ghana Education Service (Akyeampong and Furlong 2000). The teacher training college curriculum can be classified under three main sections: General Education (30 percent), Academic Education (30 percent), and Professional Education (40 percent). General education comprises eight 'core' subjects (mathematics, English language, science, physical education, cultural studies, education studies, Ghanaian language and agricultural science) and these subjects are taught in all colleges and are compulsory for all students (Akyeampong and Furlong 2000).

Under the 'academic education' component of the programme, teacher trainees specialise in two elective subjects chosen from science-based subjects (group one) or vocational subjects (group two). Subject availability varies from college to college, with some specialising in group one subjects and others in group two subjects (Akyeampong and Furlong 2000). The science-based subjects include: mathematics, agricultural science, science, technical skills and physical education, while the vocational-based subjects include: English literature, social studies, vocational skills, French and life skills. The professional education component of the programme requires all teacher trainees to undertake teaching practice activities in basic schools, mostly in the surrounding towns/villages of the training college. Currently, the professional component of the programme has been changed from an initial duration of one-to-two months of teaching practice to a full year of teaching practice. The current structure of the programme is referred to as the "IN-IN-OUT" which means teacher trainees spend two years on campus and the last year in the field practicing their teaching.

The training of junior high school mathematics teachers is therefore characterised by these three components and mathematics is studied as a core subject for all teacher trainees during the first and second years of their teacher education programme and the trainees sit examinations at the end of each year. The mathematics syllabus for the teacher training college was developed to equip the trainee teachers with the appropriate knowledge and pedagogical skills to ensure they are competent in the teaching of the subject in the teaching field (Etsey 2005, p.65). The mathematics curriculum therefore has two components: the content and pedagogy and these are taught separately at the various colleges, even though teacher trainers are advised to integrate the two components (Mereku 1987). Furthermore, mathematics teacher trainees take elective mathematics in addition to the core courses and the elective subject includes six periods of mathematics a week in years one and two, and ten periods a week in year three (Akyeampong 2003, p.24).

2.8 Summary

This chapter has examined the development of education in Ghana before and after independence, with particular reference to junior high school education and the training of junior high school mathematics teachers. Two observations have been made. The first is that Ghana has experienced a considerable number of educational reforms since the end of the colonial era. Over time, these educational reforms have contributed to changes in the structure of the educational system, particularly at the basic level. The reforms have also contributed many changes to the school curriculum in terms of its content and pedagogy.

The second observation is that the training and development of teachers has been based on ad-hoc programmes to meet emergency situations and the needs of the education system. The expansion of the education system and the establishment of more new schools since independence have led to an increasing demand for teachers in these schools. The implementation of the numerous school curricula has been influenced by a number of factors to which the teachers' beliefs and theoretical perspectives are as important as the curricula itself. The philosophy of mathematics education in Ghana has been influenced by a shift from a behaviourist philosophy to a constructivist philosophy of teaching and learning. The next chapter, Chapter 3, will place the present study within the theoretical context of mathematics education by discussing one of the broad theoretical perspectives of the teaching and learning of mathematics which has influenced mathematics teaching in Ghana for some time now: the behaviourist theory.

PART II: THEORETICAL PERSPECTIVES

Chapter 3

Behaviourism and Mathematics Teaching and Learning

3.1 Introduction

Over the past 50 years, teaching and learning in general and, more specifically, the teaching and learning of mathematics have been dominated by behaviourist theories (Feden 1994; Orton 2004). This chapter will discuss the teaching and learning of mathematics from a behaviourist perspective with an emphasis on how behaviourism has influenced mathematics teaching and learning.

In general, this chapter links to the research problem by exploring the different teaching and learning strategies used in mathematics classrooms from a behaviourist perspective. It begins by defining the concept of behaviourism and the assumptions behind behaviourist theory. This is followed by a review of the literature on the different behaviourist teaching and learning strategies. The next section will examine the nature and characteristics of a behaviourist classroom and the roles of teachers and students in such classrooms, with particular reference to mathematics.

3.2 Definition of Behaviourism

Reber (1985) defines behaviourism as an "approach to psychology which argues that only appropriate subject matter for scientific psychological investigation is observable, measurable behaviour" (p. 86). Fontana (1995) also describes behaviourism as a developmental theory that places emphasis on the connections made between the stimulus, the response and the conditions under which they occur.

Leonard (2002) adds that “behaviourism is the belief that instruction is achieved by observable, measurable, and controllable objectives set by the instructor and met by the learners who elicit a specific set of responses based upon a controlled set of stimuli” (p. 16). Abrams and Lockard (2004) also define behaviourism as a developmental theory that contends that individuals learn or construct knowledge through stimulus-response processes. Jonassen and Jonassen (2004) describe behaviourism as being concerned with what the instructor wants the student to learn and the process is directed by the teacher. Finally, Woollard (2010, p.1) also explains behaviourism as a learning theory that focuses upon the behaviour of the learner and the change in behaviour that occurs when learning takes place

Behaviourism has been defined different by different researchers from different perspectives; however, they all share the same core belief, that learning is a change in behaviour that is publically observable (Freiberge 1999). The behaviourist learning process involves a passive learning process where students learn by absorbing information from different sources and it focuses on the external behaviour of the learner (Battista 1999). A main proponent of the psychological theory of behaviourism was Skinner, who, following the work of Pavlov, Watson and Thorndike, set the precedents of behaviourist theory and its application to teaching and learning. For example, Pavlov’s ‘Classical Conditioning’ study showed that whenever there was a conditioned stimulus (a bell) there would be a conditioned response (dog salivating).

However, when the stimulus was present without a reward for some time, the conditioned response would cease, thus suggesting that when a certain stimulus is given a particular response or behaviour will be produced (Swan 2006). Watson further built on Pavlov’s ‘Classical Conditioning’ and suggested that change in behaviour was the result of precise stimuli. Skinner’s work also adds that, with the presence of motivation, behaviour is expected to repeat itself; however, when punishment is introduced, it will instead decrease this change in behaviour which he classified as operant conditioning (Kearsley 1994).

In general, a behaviourist learning paradigm represents a stimulus-response framework, where learning is considered to be the association formed between stimuli and response or the production of changes in response to the stimuli from the individual's environment (Skinner 1968). The construction of knowledge within this paradigm is therefore characterised by a change in behaviour and an assumption that all learning processes are fully controlled and influenced by the individual's environment (Skinner 1968). The importance of measuring an observable performance and the impact of the environment on the individual's learning process forms the fundamental principles of behaviourist approaches to learning (OTLN 2002, p.1).

The basic principle of behaviourism is that when behaviour is positively reinforced it will reoccur, and intermittent reinforcement is particularly effective when information is presented in small amounts (Kearsley 1994). According to Driscoll (2000), learning from a behaviourist viewpoint is based on "persisting change in performance or performance potential that result from experience and interaction of the world" (p.3). Gagné *et al.* (1992) argue that learning involves practicing each performance until fluency is attained, after which the learner combines this knowledge with a new and more complex performance from his/her environment to generate new knowledge.

The learning of mathematics within this paradigm is composed of a set of tasks to be learned in a hierarchical order, whereby the individual learner has to master the subordinate elements of the mathematical concept to be learnt (Gagne 1985). The development and creation of new mathematical knowledge occurs through the learning of rules. The fundamental principle behind this approach to learning is the use of simple tasks as a prototype to gain mastery of the fundamental concepts associated with the topic to be learnt, and it is when the learner acquires mastery of these fundamental principles that we presume that learning has taken place (Scandura 1983). For example, in mathematics, the addition of numbers is used as a prototype for learners to gain mastery of addition before they are introduced to multiplication, as multiplication is considered to be a repeated method similar to the addition of numbers.

The hallmark of behaviourism is that learning can be adequately explained without referring to any unobservable internal states. Three tenets underpin behaviourism:

- Learning consists of building connections between stimuli and responses and only responses to external stimuli are considered important.
- Tasks are subdivided into their components so that the objectives of learning and, if necessary, the pre-requisites for tackling a task, can be set – in other words, what one must be able to do before tackling the next task. The simplest components are taught first, reinforced and then built into increasingly complex hierarchies.
- Reinforcement shapes behaviour and this reinforcement consists of knowledge of results and 'rewards' for fulfilling the requirements of the task. Reinforcement schedules can be used to shape behaviour. An element of this view is the use of rewards in the form of marks linked to achievement of 'intended learning outcomes' (Brown 2004, p. 9).

3.3 Nature of Behaviourist-Based Mathematics Lessons

According to Battista (1999), the nature of behaviourist-based mathematics lessons follows a typical sequence where the lesson is normally started with a review of learners' prior knowledge or concepts. This is then followed by an introduction to the new material or concept, in which the teacher shows examples and explains how to solve a particular problem and which method to use. Battista adds that after the students have been shown how to solve the problem and which method to use, they are then given a series of questions to practice the new skill and further practice is often provided through assignments and homework. This process of reinforcement is aimed at helping students to master the procedure or the approach used in solving such problems for future application.

Most mathematics classrooms are characterised by rote learning, memorisation and drill; teaching strategy involves the presentation of instruction in small frames, allowing students to work individually at their own pace to provide immediate feedback (Swan 2006). Students in such classrooms develop new knowledge by imitating their teachers' demonstrations and working on examples from textbooks, which involves memorising and learning the procedures needed to solve a particular problem (Battista 1999). In the behaviourist classroom, students are mostly expected to produce the desired response which demonstrates students' learning and the acquisition and creation of new knowledge (Sun 2009).

The role of the teacher in the teaching and learning process is to provide a set of stimuli and reinforcements that will help the student to "emit" behavioural responses considered to be appropriate by the teacher (Glasserfeld 1989). Confrey (1990) notes that, in behaviourist lessons, the teacher is considered to be the custodian of knowledge and students rely most often on their teacher's knowledge to create new knowledge. Confrey adds that such classrooms are characterised by students answering factual questions on the topic to be learned. The level of understanding is always the sole decision of the teacher and students in such classrooms accept the teacher's answers and decisions without question.

Indeed, according to Boaler and Greeno (2000), behaviourist mathematics lessons are characterised by a teacher-centred approach to teaching, where the teacher's explanations are highly valued and students accept these explanations without question or asking for any justification. Boaler and

Greeno further add that in such lessons any explanations offered by students which differ from that of the teacher are normally considered to be invalid and usually students' misconceptions are not given the necessary attention. Boaler and Greeno explain that, despite the importance of students' misconceptions and mistakes in promoting new knowledge, mistakes among students are not encouraged, as only right responses are acknowledged. Boaler (2008) adds that in such lessons students sit individually and the teacher presents new mathematics concepts and skills and students work through short and closed problems.

In general, behaviourist based mathematics lessons involve short, procedural and closed ended questions with very few or no open ended questions and the search for correct answers (Boaler 2009). Students in such classrooms have to sit back and watch their teacher demonstrate the mathematical methods that they are expected to learn and the students must work through a number of examples by following their teachers' methods. Students are introduced to different procedural approaches that they learn to follow in order to master the mathematical skills and concepts presented to them. The teacher, who is considered to be the custodian of knowledge, therefore has the responsibility of choosing a teaching strategy that will help the students to solve different problems.

3.4 Behaviourist Teaching Strategies

Educators who base their pedagogies on behaviourism believe that students learn in a structured and procedural manner and the individual student plays a passive role in the teaching and learning process (Ball and Kuhs 1986). Lord (1999) explains that the behaviourist method of teaching assumes that all students have the same level of background knowledge in the subject matter and are able to absorb the material at the same pace. Stofflet (1998) and Cohen *et al,* (2004) describe behaviourist teaching strategies as methods that are intended to induce learning through reception, and the learner is expected to incorporate the concept of material presented into existing knowledge. Cohen *et al.* (2004) describe this approach to teaching as teacher-centred, since the teacher transmits information to the learner, who accepts and assimilates this new information into their existing knowledge.

The classroom is a place for learning and “learning is based on what happens in the classroom, and thus, learning is dependent on how the teacher structures the learning environment and not what the student does” (Fennema and Franke 1992, p. 155). A broad body of literature has been published describing and analysing the different teaching strategies that are used in the teaching of mathematics in behaviourist classrooms. My review of related literature on teaching methods has delineated the following strategies of mathematics teaching: dogmatic method, lecture method and content-focused method

Dogmatic Teaching Method

Adetunde (2007, p.342) describes this strategy as the process by which the teacher emphasises the use of rules and principles that students have to follow in solving any given problem. He argues that the teacher in this case is considered to be the *owner* and giver of information and the student is always at the receiving end, sitting back quietly and listening to their teacher and copying notes. Ellsworth and Buss (2000) explain that the dogmatic method of teaching focuses on the provision of correct answers and students are encouraged to master the procedures that will provide these correct answers.

This method of teaching is still advocated by many for several reasons. For instance, the dogmatic teaching method is an effective means of teaching different mathematical concepts, skills and relationships that exist by pure definition (Cangelosi 1996; Boaler and Greeno 2000). It is often a quick way to address course objectives and curriculum goals with strict timeframes and expectations (Jenkins 2000). It is considered to be time saving and involves less '*useless*' thinking, since students are guided by given rules and they must simply apply these rules to find answers to given problems (Adetunde 2007).

Despite these benefits, Ellsworth and Buss (2000) suggest that an emphasis on correct procedures and answers only leads to passive participation among students, which negatively affects their attitude and achievement. This method of teaching only promotes procedural learning among students, whereby students learn the rules and procedures to solve problems rather than gaining a conceptual understanding of mathematical concepts and principles. Although there is no *royal* method for teaching every topic in mathematics, the dogmatic approach does not provide the skills needed for students to make informed judgments and to transfer the application of these skills to real life situations (Nabie 2001; Abrams and Lockard 2004).

Lecture Teaching Method

The lecture method is considered to be the most established way of teaching and is found in most mathematics classrooms. Davis (2004) establishes that mathematics teachers use the lecture method of teaching even in primary schools when children are supposed to explore and interact with their immediate environment to create new knowledge. In this method, lessons are presented in the form of explanations and the teacher, as the instructor, presents the concept to students in the form of a speech or one way communication (Adetunde 2007). The lecture method is a means by which an instructor presents the materials of the course in a sequential and organised way. The instructor is the central focus of information transference, and the students in the audience must listen and sometimes take notes during the process. In classrooms where a lecture method is the mode of instruction, there is little or no interaction between the teacher and students and student-

student interactions do not normally take place, as this method is one-way communication with the instructor doing all the talking.

Many people advocate the lecture method for several reasons. Most teachers use the lecture method because that was how they were taught during their secondary and teacher training education (Chapman 2007). The lecture method is the most efficient method of presenting many facts and a mass of material in a short time and it is an effective method for teaching large groups (Battista 1999). However, despite these advantages, the lecture method provides limited or no interaction between the teacher and the students and, in most cases, students in such classrooms play passive roles in the teaching and learning process (Nabie 2001). The lecture method only promotes procedural understanding of mathematical concepts and students who experience such teaching practices are only able to answer factual questions; most of the students struggle with questions which involve the application of concepts learnt (Osafo-Affum 2001; Fletcher 2005).

The main difference between the dogmatic and the lecture method of teaching is in the former the teacher gives the students the formulae to use, tells students what to do, what to observe and the kind of conclusion to draw. The main feature of the dogmatic method is that there is no student participation in the teaching process. In the latter method, the teacher comes with prepared information and talks, with students sitting back silently and listening attentively, again without participation in the teaching process.

Content - Focused Teaching Method

According to Ball and Kuhs (1986), educators who adopt this method focus on the presentation and understanding of mathematical content. In this method, teaching concentrates on the whole class, and all students are considered to have the same learning ability and background knowledge. In such classrooms, the individual learner's unique characteristics and capabilities are of little or no importance in the teaching-learning process.

The teacher presents materials in an expository style, demonstrating, explaining and defining the concepts and skills that students have to learn while they listen and participate in didactic interaction (e.g. responding to teacher questions) and solve questions using the procedure modelled by the teacher (Ball and Kuhs 1986, p.22-23). The content-focused method of teaching therefore places emphasis on students' performance and mastery of mathematical rules and procedures and is mostly examination oriented (Thompson 1992). One of the major characteristics of this method is individual learning and competition among students. This, therefore, calls for the representation of ideas in a variety of ways and the use of alternative approaches to solve problems for students to understand.

Another feature of the content-focused classroom is the measurement of observable behaviours, where students are considered to have learned new knowledge when they are able to produce correct answers through, for example, the use of algorithms and recitation of definitions (Thompson 1992). In such classrooms, knowledge is constructed by the teacher and students have to learn factual knowledge by imitating the teacher. In these situations, as the teacher is considered to be the custodian of knowledge, the individual teacher's knowledge of subject content plays an important role in the teaching-learning process. The teacher needs a solid foundation in mathematics since he or she must take absolute control of the teaching and learning process (Ball and Kuhs 1986). The teacher is therefore more than a facilitator and he/she plays an active role in the teaching and learning process by directing almost all the classroom activities. The students are required to show mastery of the concepts, skills and procedures that they have been taught (Thompson 1992).

3.5 Behaviourist Learning Strategies

The classroom ethos has considerable potential to support or deny students' access to the mathematical concepts that they have learned and need to apply in their daily activities. What happens in the classroom shapes students' experience of learning and being taught mathematics (McMahon 2001). That is, in behaviourist terms, the environment can positively or negatively reinforce the teaching and learning of mathematics. Lampert (1990) argues that the way the subject is taught impacts on the individual student's learning experiences and how he/she constructs new knowledge.

Learning is "persisting changes in performance or performance potential that result from experience and interaction with the world" (Driscoll, 2000, p.3). Learning from exposure is characterised by the acquisition of information that is presented in sequential order and in smaller parts and the mastery of the process involved is a pre-requisite for the creation of new knowledge (Thompson 1992). Thompson further adds that behaviourist learning strategies are characterised by passive learning experiences with little or no participation.

According to Battista (1999), behaviourist learning strategies involve absorbing information from different sources and an endless sequence of memorisation of facts and formulae. Roj-Lindberg (2001) argues that such learning strategies do not offer students the opportunity to discuss and talk through issues to develop new knowledge and, in most cases, students learn the subject in a passive way. Roj-Lindberg explains that passive learning takes place when the teacher transmits information to the students and the students are expected to use the information provided to solve mathematical problems by following procedural rules.

Battista (1999) opines that the behaviourist approach to learning is common in most mathematics classrooms, where it has been the norm for the past four decades. Students' experiences of learning mathematics at school leave them with both qualitative and quantitative variations in their understanding and contextual development of mathematics concepts and skills after their studies. Brown and Borko (1992) agree that the kind of attitude and outlook that students have towards mathematics in later life is the result of the type of experiences they have had over the years. For example, Crawford *et al.* (1998), in their research involving 300 undergraduate students, establish that there is a direct relationship between students' prior experiences and learning approaches. Students' experiences and perceptions of mathematics were associated with their approaches to learning mathematics and how they were taught. Crawford *et al.* add that students who experience mathematics in behaviourist classrooms at their primary and secondary level adopt a passive learning approach which involves the mastery and application of mathematical formulae at their undergraduate level.

3.6 Concerns Associated with the Behaviourist Approach

Critics of the behaviourist approach to teaching and learning in general and specifically in mathematics education argue that, although the creation of knowledge involves some level of stimulus-response approach as argued by the behaviourist paradigm, it does not end there. Boulding (1984) questions Skinner's and Pavlov's principle of applying animal behaviour to the complex nature of humans. It cannot account for all types of learning or knowledge that the individual acquires, as it does not take into account the activity of the mind; it only focuses on the external environment and how it affects learning. According to Naik (2003), the behaviourist rejection of the individual's mental process and how the individual constructs knowledge in their assumptions invalidates its ability to explain human behaviour and how people learn.

Berglas (2002) argues that behaviourism is a one-dimensional approach to behaviour and does not account for free will and internal influences such as the moods, thoughts and feelings of the individual. The behaviour of the individual learner is not limited to external influences. How the individual uses his/her external experiences to construct new knowledge is dependent on the individual's thoughts and ability to comprehend these experiences internally. The creation of new knowledge goes beyond observable external behaviour, which avoids reference to meaning, representation and thoughts (Davis and Davis 1998). Abrams and Lockard (2004) also explain that "the core of behaviourism, the reinforcement principle, does not adequately explain the complexity of thinking, memory, problem solving, and decision making" (p. 6).

Stiff *et al.* (1993) argue that the teaching of mathematical concepts goes beyond the mere stimulus-response approach; learning requires the active participation of students in the teaching process. Nickson (2000) also suggests that behaviourism is characterised by competition and individual work and always targets the brilliant student at the expense of the average and below average students.

Despite these limitations, for a long time the theoretical underpinning of much of the teaching of mathematics has been heavily influenced by the behaviourist approach. Peltier (2001, p.47) considers that the "thoughtful application of behavioural principles ought to form the foundation of any healthy and productive organisation." Jaworski (1994) also establishes that the instructional practices of most mathematics classrooms are still influenced by the principles of behaviourist theory. Boaler (2009), in her recent study, has also found that most mathematics classrooms are still characterised by behaviourist activities that are results oriented; once students are able to produce the correct responses, learning is believed to have taken place.

Researchers like Jaworski (1994) and Orton (2004) argue that, despite its limitations, behaviourism cannot be ignored completely in the teaching-learning process. Jaworski believes that the behaviourist approach will continue to exist in most classrooms because of its important application in some aspects of the mathematics curriculum. According to Orton (1993; 2004) and Mathews (1997), the teaching of elementary arithmetic such as multiplication tables still requires some practices associated with behaviourist theory such as memorisation and rehearsal. In addition, despite the limitations of behaviourist theories of learning, most mathematics curricula have a mental arithmetic component in which students are expected to remember some basic mathematical concepts and skills (Mathews 1997).

Research by Lim (2007) shows that mathematics teaching and learning in China and most other Asian countries is characterised by passive transmission, rote drilling and memorisation of facts and procedures. Yet Chinese students excel in most international comparative mathematics achievement studies, despite experiencing mathematics in a behaviourist way. Lim reports that, apart from the classroom activity characterised by passive learning experiences, the teacher utilised an *exemplary* approach of teaching whereby different examples and different methods of solving problems are used to explain the concept to the students. It can, therefore, be argued that the application of the behaviourist approach to the teaching and learning of mathematics, along with the promotion of some elements of students' active participation, can promote 'effective' teaching and learning.

3.6 Summary

This chapter has provided a review of literature about the teaching and learning of mathematics from the behaviourist perspective. The review of the related literature involved the teaching and learning strategies used in behaviourist classrooms and the role of the teacher and the student in the teaching and learning of mathematics. A summary of the key points discussed in this chapter includes: the meaning of behaviourism and its key principles, teaching and learning approaches, and the limitations of behaviourism. The behaviourist theory of learning is therefore considered to be a developmental theory that measures observable behaviours produced by a learner's response to stimuli. The main tenet of the behaviourist theory of learning is that knowing or learning something is one's ability to give the correct response when one is exposed to various learning stimuli (Gagné *et al.* 1992; Swan 2006).

In the behaviourist classroom, learning is considered to be a change in behaviour due to experience and putting these experiences into practice to produce results by engaging in trial and error (Deubel 2003). Teaching, from the behaviourist perspective, is based on direct transmission of information from the teacher to the learner through the use of teacher-centred approaches. Students learn or construct new knowledge by producing the correct feedback after a stimulus is applied or by practising each performance to gain mastery of it (Kearsley 1994). The major criticism of behaviourism is its one-dimensional approach, which neglects internal influences such as emotion and thoughts in the creation of new knowledge.

Having discussed the understanding and impact of the ideas of behaviourism on teaching and learning, the next chapter will explore how constructivism, another broad theoretical perspective in mathematics education, has influenced mathematics teaching and learning.

Chapter 4

Constructivism and Mathematics Teaching and Learning

4.1 Introduction

This chapter will discuss constructivist perspectives on mathematics education. It will begin by examining the different ways in which the term constructivism has been defined by different authors and researchers. The second section examines the nature of mathematics lessons based upon constructivist principles and the third section examines the teaching strategies associated with constructivism. The fourth section discusses the learning strategies associated with constructivism and the last section discusses the limitations of constructivism and its implications for mathematics teaching and learning.

4.2 Definition of Constructivism

The constructivist theory is grounded in the works of Piaget, Vygotsky, Bruner and the philosophy of John Dewey. A variety of differing views are found within constructivism, as the concept has been defined differently by various researchers and authors (Woolfolk *et al.* 2008). For example, Confrey (1990) defines constructivism as “a belief that all knowledge is necessarily a product of our own cognitive acts” (p. 107). Similarly, Lowery (1997) sees constructivism as a philosophy that states that students construct new knowledge and understanding for themselves. Lambert *et al.* (1995) describe constructivism as a theory of learning which contends that "individuals bring past experiences and beliefs, as well as their cultural histories and world views, into the process of learning; all of these influence how we interact with and interpret our encounters with new ideas and events" (p. xii). Within this paradigm, the individual learner constructs his/her own knowledge from experiences and interaction with the physical world (Doolittle and Camp 1999).

Fosnot (1996) holds that constructivism is a psychological theory which construes learning as an interpretive building of process whereby the individual learner actively interacts with the physical and social world. According to Jonassen (1997) and Orton (2004), within this paradigm students are given the opportunity to utilise their prior knowledge, experience, observation and understanding to formulate new concepts and the emphasis is on concept formation rather than teaching for concept acquisition, as experienced in behaviourist classrooms.

In general, constructivist theories are theories of learning that provide teachers and educators with an understanding of how students learn; they are underpinned by two main principles: “that learners are active in constructing their own knowledge and that social interactions are important to knowledge construction (Bruning *et al.* 2004, p.195). The individual learner constructs and gains new knowledge through experience, interaction and active involvement with the learning environment. Learners create knowledge by building on previously constructed knowledge and students can better grasp the concepts and move from simply knowing the material to understanding it (Ward 2001). Within constructivist theory, it is believed that students move from the known to the unknown and possession of a solid foundation of a particular concept is considered to be paramount, as the development of new knowledge is dependent upon what is already known.

4.3 Nature of Constructivist-Based Mathematics Lessons

Constructivist based mathematics lessons are characterised by student-centred instruction; students are introduced to varying methods of solving problems with different opportunities for students to create their own knowledge. That is, learning activities in constructivist classrooms or lessons are characterised by active engagement, reflective thinking and problem solving (Abrams and Lockard 2004). The acquisition of knowledge is affected by the external world within which the individual learner finds him/herself and it is based on the individual's ability to use his/her cognitive structures to construct knowledge for him or herself (Glasersfeld, 1989).

According to Ward (2001), the teacher plays an important role in assisting and guiding students in constructing accurate knowledge as they experience the environment and come into contact with different forms of ideas. In such classrooms, the teacher acts as a facilitator in the teaching-learning process by providing opportunities for students to learn and construct knowledge. The role of the teacher is to act as a knowledgeable adult who supports the learner to achieve ends that would be unattainable if the student worked on his/her own (Goodchild 2002b). One of the main features of a constructivist classroom is social interaction. According to Blanck (1990, p.44), individual mental activities are uniquely human and the individual's creation of knowledge is to a large extent influenced by his/her innate capabilities and characteristics. Blanck, however, adds that, despite the importance of the learner's innate characteristics, the environment influences the creation of new knowledge. The learner is more likely to retain this new knowledge for a longer period of time if it is constructed through active interaction with the learning environment; giving the learner the opportunity to explore his/her environment helps them to retain newly constructed knowledge and take responsibility for their own learning (Goodchild 2002b).

Vygostky (1978) argues that learning first occurs in an interpersonal manner, after which it is internalised by the individual learner. Vygostky considers how students attain a high level of thinking and the formulation of the higher order concepts and skills that they need when they interact with their peers. According to Vygotsky, the individual learner is able to move from their respective lower levels of thinking to higher levels of thinking when they are guided by a knowledgeable adult or peer. The gap between a lower level of thinking and a higher level is what Vygotsky refers to as the Zone of Proximal Development (ZPD). He describes the Zone of Proximal Development (ZPD) as the gap between what the individual learner/student knows and what he/she does not know, which may require a higher order of thinking than the student possesses. The development of this higher order of thinking is influenced by the nature of the activities presented to the students, and the more these activities are able to interrupt the flow of the students' activity and thinking, the more likely they will reach that higher level of thinking. Goodchild (2002b) explains that presenting students with challenging activities will help them to move from their current level of understanding to a higher level.

In general the constructivist classroom environment is characterised by student-centred learning activities and the role of the teacher is to provide varying opportunities for students to create new knowledge. Students must therefore be actively involved in the learning process in order to develop an adequate understanding of each concept and move to a higher level of thinking (Abrams and Lockard 2004). Vygostky's ideas of social interaction with guidance from a knowledgeable adult suggest that students "can perform at a developmentally more advanced level when assisted than when acting alone, and this difference in performance means that a learner has a range of potential rather than some fixed state of ability" (Vygotsky 1978, pp 195-196). The individual learner has the ability to create new knowledge and find solutions to problems and this range of potential therefore requires the provision of varying learning opportunities to develop this ability.

4.4 Constructivist Teaching Strategies

The constructivist theory is based on the principle of encouraging students to confront, construct and develop new knowledge by actively taking part in the teaching and learning process through social interaction (Glasersfeld 1989). For students to develop and create their own knowledge, they have to participate in a series of activities designed by a knowledgeable adult which aim to provide the individual student with varying opportunities to learn. The student's ability to develop new knowledge using his/her existing experience is dependent on how the teacher presents the concept and the teaching method used.

According to Zhao (2003), the "characteristics of constructivist teaching models include: prompting students to observe and formulate their own questions; allowing multiple interpretations and expressions of learning; encouraging students to work in groups; and in the use of their peers as resources to learning" (p. 98). In the view of Cohen *et al.* (2004), constructivist teaching methods are intended to induce learning through discovery and investigation, classified as open or discovery methods. Constructivist teaching methods are student-centred, with an emphasis on the creation of an enabling environment for the student to explore and develop new knowledge (Zhao 2003). Group work methods, discovery or investigative method and a learner-focused approach are the strategies distinguishable in the literature.

Group Work Approach

Group work methods of instruction are one way in which the constructivist theory has been conceptualised in relation to classroom practice. The group work approach to teaching has been used in two different ways: as an instructional method and as a learning tool which provides teachers with an understanding of how students learn (Zakaria and Iksan 2007). Zakaria and Iksan describe group work as an instructional method of teaching, where the teacher provides opportunities for students to learn cooperatively in groups. Through such group work, the teacher is able to understand how students think or learn by assessing the work and feedback from individual groups and individuals in each particular group.

From the viewpoint of Caplow and Kardash (1995) and Dobbins (1999), educators who base their pedagogies on group work believe that students learn in a less structured and more social environment through learning together. Caplow and Kardash (1995) see group work as a process in which "knowledge is not transferred from expert to student, but created and located in the learning environment" (p.209). Other researchers see groups as a form of critical pedagogy that moves classroom and society closer to each other, thereby making knowledge acquired in the classroom more applicable in solving societal problems (Ma 1996; Elbers 2003; Chapman 2004; Hanze and Berger 2007).

In general, a group work approach to teaching aims to promote cooperative learning among students, whereby individual learners interact with one another to create new knowledge. The creation of such new knowledge is dependent on the individual's prior knowledge and the conditions of the individual's learning environment and the kind of people with whom the individual learner interacts. According to Vygotsky (1978), the intellectual development of the individual learner can only be understood when reference is made to the social setting in which the learner finds him/her self. He adds that, although the social setting and the individual learner's active participation in the teaching-learning process play an important role in the creation of knowledge, interaction with a knowledgeable adult or a more competent set of students is essential for cognitive development. Although students in a group may have different abilities, experiences and Zones of Proximal Development, "learning is most effective when students are actively involved in sharing ideas and work cooperatively to complete academic tasks" (Zakaria and Iksan 2007, p.36)

The advantages of group work as a method of teaching have been broadly discussed in the literature by a number of researchers. Research by Ma (1996) has established that group work promotes a high order of thinking among students and it helps both low and high achievers gain from each other. According to Ball and Bass (2000), discussions among students or whole class discussions promote and extend learners' mathematical understanding as they have the opportunity to discuss their ideas and justify their answers and conclusions. They further add that group or whole class discussions give learners the opportunity to be responsible for their own learning and therefore develop self confidence.

Hanze and Berger (2007) also find that group work promotes self-confidence and better academic performance among students than the direct instruction method. Gillies (2003) argue that structured group work in which students are given a particular task to complete can lead to better learning outcomes. However, it is only when groups are structured in such a way that students understand how they are expected to work and are guided by the teacher that the desired results are achieved.

Boaler (2006) identifies several ways of using group work as a teaching method to ensure that students take responsibility for one another's learning. She explains that the teacher can use an assessment system in which the educator grades the work of a group by the quality of its interactions among the group members. In addition, she adds that the teacher may also promote group work involving different activities and use the work of one of the group members to grade the entire group. In such situations, all the members of the group will have to play an active role in the learning process, as the group members do not know whose work will be used to grade the whole group. Another way of promoting effective cooperative learning is through the practice of asking a student in the cooperative groups to answer a follow-up question after a group have presented their answer to a particular problem. According to Boaler (2006), if the student cannot answer the follow-up question, the teacher asks the group to go back for further discussion to help the student to understand the particular concept discussed. She adds that this approach gives individual members the opportunity to be responsible for their own learning and develop an understanding of each particular concept presented.

Discovery or Investigative Approach

This approach to teaching is the process whereby the learner becomes a discoverer by being involved in the process of creating new knowledge by discovery in the environment, and where the teacher acts as a facilitator in the teaching and learning process (Adetunde 2007). Hammer (1997) describes a discovery instruction or teaching method as a method which focuses more on the student and how the individual student interacts with his/her immediate environment to create new knowledge. Hammer further adds that within this perspective of teaching, the teacher is considered to be a reflective practitioner who improvises and creates different activities which the learner uses as a tool to develop new knowledge.

The main characteristic of this approach is that knowledge is not passively received, but constructed by the learner; how the knowledge is constructed is unique and different for each individual (Jaworski 1992). According to Jaworski, construction of knowledge involves constant exploration of the world or the immediate environment of the learner and the making of meaning from the various experiences that the individual learner encounters. This approach to teaching involves the creation of diverse opportunities so that the individual learner can explore the topic from different perspectives to develop new ways of thinking (Nabie 2001). The major tenet of this approach to teaching is therefore the provision of opportunities for students to practice a variety of procedures and explore new solutions, using an assortment of methods and employing cooperative learning (Nabie 2001).

In general, this method brings about diversity in the teaching and learning process and helps students to practice beyond the classroom on their own and be responsible for their learning. Some of the reported benefits of this approach include increased enjoyment and understanding as well as the boosting of the individual student’s morale and the ability to transfer the acquired knowledge to other disciplines (Nabie 2001). However, despite the numerous advantages of this method, the use of the discovery teaching method in which students are allowed to explore and discover new knowledge may also lead to students discovering and developing inaccurate ideas (Hammer 1997). Moreover, the application of this approach in the mathematics classroom can be challenging and time consuming because of the different prior knowledge and experiences that individual students bring to the class (Nabie 2001). In general, the discovery method considers the role of the teacher to be of great importance in helping students to develop accurate ideas or using the students’ mistakes and misconceptions to develop correct ideas.

Individual Teaching Approach

Another teaching method distinguishable in the constructivist teaching literature is the individual teaching approach. Ball and Kuhs (1986) describe an individual teaching approach as a process of guiding the learner to construct new knowledge by performing a series of activities aimed to help the student to reach his/her Zone of Proximal Development. This approach of teaching mathematics focuses on the individual learner’s personal construction of mathematical knowledge through his/her active participation in the teaching and learning process (Thompson 1992). Trigwell and Prosser (1996) state that:

> This approach is one in which teachers adopt a student-focused strategy to help their students change their world views or conceptions of the phenomena they are studying. Students are seen to have to construct their own knowledge, and so the teacher has to focus on what the students are doing in the teaching-learning situation. A student-focused strategy is assumed to be necessary because it is the students who have to re-construct their knowledge to produce a new world view or conception. The teacher understands that he/she cannot transmit a new world view or conception to the students (p. 80).

This approach to teaching is a problem-centred approach to teaching and places the student at the centre of instruction and starts by giving "students a real world problem. Students are expected to determine any new concept or theoretical results which are needed to solve the problem and they are expected to do this by themselves, albeit under the guidance of the teacher" (Peng 2002, p. 12). One way in which this approach is conceptualised in the mathematics classroom is the use of different types of methods to cater for the individual student's needs and giving students the opportunity to present and explain their work in front of the class (Alsardary and Blumberg 2009, p.401). Such active participation in the teaching-learning process offers a plausible approach to classroom instruction (Ball and Kuhs 1986). Ma (1996), Kumpulainen and Wray (2002) also opine that students learn effectively when they interact with their peers and teachers and knowing this can help teachers to orchestrate effective classroom practices and also scaffold students' learning. Elbers (2003) states that this can be achieved if students are given the chance to participate in the process of knowledge construction through classroom interaction and active participation in small learning groups with peers. According to Kong *et al.* (2003), diversity in individual differences in learning is one of the major issues with which teachers have to contend in the classroom as they try to promote effective teaching and learning. They therefore propose that the individual student's disengagement from the teaching-learning process would certainly drive students away from learning. Nevertheless, some students may prefer to memorise various facts and rules in mathematics while others are involved in understanding the concepts behind the rules, but their engagement stimulates their interest in the subject. Hodson (1993), Steele (2005) and Willis

(2010) therefore agree that the best way to learn mathematics is through the personal and physical involvement of the individual learner in the teaching-learning process.

However, the mere opportunity to participate in social interaction will not necessarily lead to meaningful learning, as the creation of new knowledge requires both active participation and the process of making meaning (Kumpulainen and Wray 2002, p.3). Steele (2005), Boaler (2009) and Willis (2010) therefore advocate going beyond mere participation in the classroom to motivate students to take responsibility for their own learning. Giving the individual student the chance to present and discuss his or her work in class whilst the teacher and the other students listen and question the student about his/her approach to solving a particular problem promotes self confidence and independent learning among students (Willis 2010).

In general, the constructivist teaching method is underpinned by the principle that learners construct their own knowledge through interaction with their immediate world. The method of teaching therefore has a great impact on the individual's ability to construct his/her own knowledge, as individuals have different prior knowledge which they use to create new knowledge. In offering different constructivist teaching methods, the teacher acts as a facilitator by providing an environment conducive for education and opportunities for students to learn. In other words, one goal of the constructivist teaching approach is to free the learner from the teacher, so the learner can work independently (Woolfolk *et al.* 2008, p.403). The different teaching methods therefore lead to students learning and constructing knowledge in different ways. The next section examines the learning strategies associated with the constructivist theory.

4.5 Constructivist Learning Strategies

From the constructivist point of view, learning takes place when a schema leads to perturbation and, in turn, leads to the accommodation that establishes the equilibrium to produce the expected knowledge, as a result of interaction with the immediate environment (Glasersfeld, 1989). That is, learners construct knowledge for themselves. Individual learners are believed to have their own mental framework which is a function of their beliefs, past experiences and knowledge and when a person encounters new information, he or she understands and assimilates it in the context of their existing mental structures, thereby constructing new knowledge (Piaget 1977; Bruner 1996; Doolittle and Camp 1999).

Constructivist learning methods or approaches include discovery learning, problem-centred learning and investigation. The main characteristic of these learning strategies is that students are active learners and build on their existing knowledge to develop new knowledge. An active learning approach is "characterised by students having an intention to seek meaning and understanding of the material being studied through elaborating and transforming the material" (Dart *et al.* 2000, p. 137). Active learning approaches involve a process through which the individual student develops an understanding of a mathematical concept through a series of investigations and trial and error activities, with little or no support from the teacher (Elbers 2003; Boaler 2009). Boaler (2009) also states that active learners are usually encouraged to make mistakes and perform further investigations to correct their mistakes, rather than always aiming to achieve the right answers.

Stevenson and Stigler (1992), in their comparative analysis of American and Asian mathematics classrooms, suggest that in most classrooms where students' mistakes are regarded as an index of what still needs to be learnt, students are always given the opportunity to use different approaches and methods to solve a particular problem, thereby developing a deeper understanding of that concept. Stigler and Hiebert believe that multiple solutions to a problem promote deeper understanding among students and this is well documented in the literature of mathematics teaching and learning. Leikin and Levan-Waynberg (2007) opine that the most recognised approach in developing a deeper understanding of a mathematical concept is to solve problems in different ways.

Students' active participation in the teaching-learning process stimulates their conceptual understanding and independent learning. Students' active participation can be stimulated if the information presented is linked to real life situations, as this better presentation helps them to understand the concept and its application in solving future problems (Clarke *et al.* 2009). This approach to learning helps students to develop an understanding based upon their prior knowledge. The development of this higher order of thinking is influenced by the nature of the activities presented to the students and the language used in communicating these concepts to the learner. The more these activities are able to interrupt the flow of the students' activity and thinking, the more likely the students will reach a higher level of thinking (Vygotsky 1986). In other words, these kinds of interruptions are important as they act as stimulus to access new knowledge and higher levels of thinking. Vygotsky further states that achieving this higher level of thinking also requires the use of pseudo-concepts or symbols which resemble the actual concept and are introduced to help students make connections. The functional use of a word, or any other sign, as a means of focusing one's attention, selecting distinctive features and analysing and synthesising them plays a central role in the formation of concepts (Vygotsky 1986, p.106).

In general, constructivist learning strategies present a way of learning whereby the individual learner builds on his/her prior knowledge and understanding to construct new knowledge and understandings from authentic experience. Constructivist learning strategies are self-regulated learning strategies in which the individual learner takes responsibility for his/her own learning and engages with the environment to create new knowledge (Woolfolk *et al.* 2008). The nature of the new knowledge that is created and how it is created is dependent on the learning opportunities and experiences that the learner encounters.

4.6 Concerns Associated with the Constructivist Approach

According to Bennett (1987), progress "occurs when existing theories are found wanting and alternatives are developed to replace them" (p. 67). Although constructivism has emerged as a leading metaphor for human learning because of its underpinning principles of promoting the individual learner's active participation in the learning process, it has been criticised in many ways. Bennett (1987, p.73), for example, argues that the constructivist model of the child and, for that matter, the learner does not contain any serious treatment of the nature of the social environment in which learning takes place.

Begg (2002) believes that learning affects the entire web of being, which goes beyond cognitive knowledge, as emphasised in the constructivist theory. According to Begg, the application of a 'real constructivist' approach in the teaching and learning of mathematics is problematic and most teachers find it difficult to implement in respective classrooms. Draper (2002) explains that one of the major challenges of the constructivist approach is translating this learning theory into theory of teaching. Draper states that constructivism is a descriptive theory of learning and not a theory of teaching and the implementation of this theory requires a change in existing classroom practices.

Elbers (2003) expounds that most teachers do find it difficult to implement constructivist approaches in their classrooms due to the problems associated with their application in the teaching and learning of abstract concepts, and for several other reasons. For example, research by Mathews

(1997) has established that the application of the constructivist theory of learning in the learning of science and mathematical concepts is problematic. He finds that the creation of abstract scientific and mathematical concepts cannot be learned independently by the individual. The learner cannot understand these concepts, created some centuries ago through mere observation and experience. According to Mathews, the learner will understand these abstract concepts more and learn to appreciate how they work and their applications only when they are taught by a knowledgeable adult.

Additionally, one of the major characteristics of constructivism is cooperative or group learning. However, the application of cooperative learning in classrooms presents a number of challenges, as not all cooperative learning leads to conceptual understanding and placing students in groups and telling them to work will not necessarily promote cooperative learning (Gillies 2003). For example, Boaler (2006), in her study involving three schools in the USA, reveals that, despite the numerous advantages of cooperative learning, working in groups does not always function well and often some students do more work than others. Pijls *et al.* (2007) also establishes that “one of the difficulties for teachers is to observe the learning process of students who are working collaboratively” (p. 309). They add that seeing pairs of students talking animatedly to one another may be satisfying, but “does not tell us if they are learning mathematics and whether they support or hinder one another’s learning” (p.309).

4.7 Summary

This chapter has explored and discussed constructivist teaching and learning approaches. The related literature explores the different teaching and learning strategies used in constructivist based mathematics lessons. The key issues from the discussion are that constructivism is a theory of learning which views the internal influences of the learner as paramount in shaping the individual learner’s experiences. Group work, investigation and learner-focused methods are the major teaching strategies used in constructivist classrooms and the role of the teacher is to provide diverse learning opportunities for students to explore the different ways to solve problems. Another key issue discussed is the fact that students do not learn in isolation, but construct knowledge from their experiences and interactions with their immediate environment

The next chapter reviews related empirical research on the teaching and learning of mathematics by bringing the ideas of behaviourism and constructivism together to develop a conceptual framework for the present study.

Chapter 5

Empirical Research

5.1 Introduction

In Chapter 3 and 4, the teaching and learning of mathematics was discussed with respect to two theoretical traditions: behaviourism and constructivism. The purpose of this chapter is to review research conducted in the field of mathematics education and further develop a conceptual framework for the study. The chapter begins with a review of research findings in the area of changes in policy for the teaching and learning of mathematics, teaching beliefs and teaching practices, teachers' knowledge of their subject content, teachers' interpretations of the teaching practices, the environment and classroom learning and the framework for analysing mathematics lessons. Moreover, the chapter aims to establish a conceptual framework for the present study by drawing upon the principles of the theoretical traditions of behaviourism and constructivism and empirical research findings.

5.2 Theoretical Shifts in Mathematics Teaching and Learning Policies

It was revealed in Chapter one that improving the teaching and learning of mathematics has been an ongoing issue across the world for some time now. However, the National Council of Teachers of Mathematics (NCTM) *Agenda for Action* in 1980, which was documented in 1989, provided a new wave of change affecting how mathematics is taught and learnt in schools. In the agenda, it was noted that there was the need to pay particular attention to *how* mathematics is taught instead of concentrating on *what* mathematics was taught in schools (NCTM 1989). The 1980 Agenda for Action therefore aimed to provide a framework for guiding reforms that provide effective and efficient teaching and learning strategies. Although the National Council of Teachers of Mathematics (NCTM) is an American organisation, it has an international influence on mathematics education policies in most countries and Ghana is no exception.

These changes were intended to increase students' participation and engagement in the teaching-learning process by decreasing memorisation of algorithms and reducing teachers' role as the disseminators of knowledge in order to transform them into facilitators in the teaching-learning process (NCTM 1991). The advantages of promoting students' active participation in the teaching-learning process were clearly outlined in the policy document. According to the NCTM (1989) report:

> If students are exposed to the kinds of experiences outlined in the Standards, they will gain mathematical power. This denotes an individual's ability to explore, conjecture, and reason logically, as well as the ability to use a variety of methods effectively to solve non-routine problems (p.5).

The type of mathematics classroom environment envisioned in the 1980 Agenda for Action was a shift from procedural to the conceptual teaching and learning of mathematics. These shifts therefore imply a move from a traditional way of teaching and learning mathematics, characterised by the principles of behaviourism, to a transformed approach exemplified by the principles of constructivism. These shifts require the provision of opportunities for all students to learn important mathematical concepts and processes with understanding (NCTM 1991). Achieving this vision requires "solid mathematics curricula, competent and knowledgeable teachers who can integrate instruction with assessment, education policies that enhance and support learning, classrooms with ready access to technology, and commitment to both quality and excellence" (NCTM 2000, p.3).

Restructuring of the mathematics curriculum in almost every part of the world over the last two to three decades has therefore been influenced by the NCTM standards and most of this restructuring came about in the late 1980's. According to Liu and Li (2010), the Chinese mathematics curriculum experienced dramatic changes in the late 1990's and the changes included "many different aspects of mathematics education ranging from what is valued for all students to learn, how mathematics should be taught and learned, and how the assessment should be viewed and used" (p. 10). Liu and Li state that the purpose of the dramatic changes was to help and motivate students to learn mathematics through creativity and independent learning which stimulates students' conceptual understanding and interest.

In the United Kingdom, although changes to local curricula, published teaching schemes and the move to constructivism started in the 1960s, reforms of mathematics teaching and learning started in the late 1980s with the introduction of a national curriculum and new instructional practices (Chambers 2008). Chambers believes that the new curriculum was therefore aimed at providing a new mathematics classroom environment to promote conceptual understanding of mathematical concepts and skills through problem solving. In Ghana, the restructuring of the mathematics curriculum started in the late 1980s on a pilot basis and was adopted by all schools in the early 1990s, with the intention of shifting the teaching and learning of mathematics from the direct instruction method to a constructivist approach. These ideas have been echoed explicitly in the new mathematics curriculum introduced in 2007, to promote the effective teaching and learning of mathematics.

Almost every country has experienced some dramatic changes in their mathematics curriculum over the last two decades, with the aim of changing the teaching and learning of mathematics. Since the introduction of the National Council of Teachers of Mathematics *Agenda for Action* in 1980, the call for changes in the way mathematics is taught and learned based on constructivist principles has been receiving significant international recognition and support and has greatly influenced the teaching and learning of the subject (Jaworski 1994). The acknowledgement and adoption of constructivist principles is thanks to the numerous advantages associated with constructivism. For example, according to Buerk (1994), since the introduction of constructivism into mathematics classrooms, the thinking and perception of mathematics has been changing. Buerk further reveals that students have been discovering "the beauty, the joy and the power of mathematics…Math is alive, flexible and inherently interesting…fundamentally obvious…common sensically accessible" (p. 13). Caprio (1994), in his comparative study observing a traditional classroom and a constructivist classroom, has established that students in the constructivist classroom were more confident of their learning and took responsibility for their own learning, when compared to their colleagues in the traditional classroom. Ahmed *et al.* (2004) argue that the use of concrete materials, one of the principles of constructivism, and everyday examples stimulate students' interest and participation, as they will be aware of the importance of the mathematical concepts with which they are presented and how they could be applied in real life situations.

Felder (1993) explains that individuals, and for that matter, students, differ considerably in how they learn and test their understanding, knowledge and skills. He further adds that each individual has his/her own academic learning strengths and weaknesses which can be determined by the combination of heredity and the environment within which the individual finds his/her self. It can also be argued that, apart from the individual student taking an active role in the teaching and learning process, the way the individual student learns plays a crucial role in his/her knowledge construction and understanding of mathematical concepts. Hargrove *et al.* (2008, p.38) suggest that one of the major steps towards increasing students' learning, experiences and conceptual understanding of mathematical concepts is through understanding the way they individually learn.

In addition, Peters *et al.* (2008) states that whether we are able to provide all the teaching and learning materials needed for a particular lesson, or choose to adopt the latest technology or maintain the traditional "chalk talk" methods of teaching, affects what students do and how they learn which plays a crucial role in the teaching and learning process. That is, the individual student's ability to learn and understand a particular concept or skill depends on how the individual is able to use what he/she encounters and their existing knowledge to construct pieces of information for possible assimilation and accommodation. Students are able to conceptualise and give meaning to new encounters if they are able to assimilate their fresh events with their previous experiences. Felder (1993, p.286) argues that:

> Students whose learning styles are compatible with the teaching styles of the course instructor tend to retain information longer, apply it more effectively and have more positive post-course attitude toward the subject than their counterparts who experience learning/teaching styles mismatched.

According to Mercer (1995), apart from presenting information in diverse ways to meet the individual student's way of learning, promoting students' active participation, classrooms in which the proportion of input from students is higher than that from the teacher show active participation is desirable. Mercer further argues that, in such classrooms, students' contributions are much higher than in a class in which the student has less input. Boaler (1998) explains that giving students the opportunity to express their views and thoughts and to be heard not only promotes active participation in the teaching-learning process, it also motivates students and encourages independent learning among students. Mapolelo (2009) establishes that encouraging students to play an active role in the teaching-learning process helps students to reflect on their thinking and develop new knowledge, which can be applied when solving real life problems.

Despite the importance of the individual learner's active participation in the teaching and learning process, research has shown that behaviourist learning strategies are common in most mathematics classrooms in which teachers speak most of the time while students only listen (NCES 1999; Stigler et al. 2000). For example, Stigler *et al.* (2000), in their comparative study of mathematics instruction in three countries, namely Germany, Japan and the United States, establish that in all three countries teachers talk more than students and the estimated ratio was 8:1 teacher to student input. In general, the teacher-student relationship and participation in the teaching-learning process promotes quality learning; however, most mathematics classrooms are characterised by behaviourist approaches to learning whereby the teacher does nearly all the talking.

The adaptation and implementation of these new ideas and curricula relies on teachers' understanding of the curriculum guidelines and teachers' commitment to implement it (Ernest 2001). The mere introduction of a new curriculum does not promote the desired effect on teaching and learning, as teachers hold different theoretical perspectives, beliefs and understandings regarding their pedagogy.

5.3 Teachers' Beliefs about the Teaching and Learning of Mathematics

In the above discussion, it is argued that, internationally, a policy shift towards constructivism can be identified as an aim of every new mathematics curriculum due to their accompanied teaching and learning guidelines. However, behaviourist principles also remain part of the teaching-learning process in mathematics classrooms. In addition, independent of the approach required by policies, an individual teacher's beliefs and theoretical view points are very important. According to Hersh (1986):

> One's conceptions of what mathematics is affect one's conception of how it should be presented. One's manner of presenting it is an indication of what one believes to be most essential in it ... The issue, then, is not what is the best way to teach? but, What is mathematics really all about? ... Controversies about high school teaching cannot be resolved without confronting problems about the nature of mathematics (p. 13).

The implementation of constructivist principles and a change in the way a teacher teaches do not happen by chance, but are influenced by the individual teacher's beliefs about the subject. How the individual perceives and understands the nature of mathematics predicts his/her view of how it should be taught and learned (Hersh 1979; Ernest 1989). Ernest (1989) opines that "teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics teaching and learning change consistent with the policy documentation" (p. 249). That is, a change of approach to the teaching of mathematics "depends fundamentally on the teacher's system of beliefs, and the teacher's conception of the nature of mathematics" (Ernest 1994, p.1). Ernest further adds that the implementation of a curriculum change cannot take place unless teachers' deeply held beliefs about mathematics are consistent with the curriculum recommendations.

Thus the literature confirms that teachers' approaches to mathematics teaching depend on their beliefs and the conceptions that they have. According to Ernest (1989), two teachers may have similar knowledge, but might have different beliefs. That is to say, if a teacher views mathematics from a traditional perspective and therefore sees the subject as the mastery of symbols and procedures to solve a particular problem, then that person will teach using a didactic approach (Hersh 1979; NCTM 1995). A teacher with a traditional approach to mathematics will consider the subject to be an unrelated collection of facts and is most likely to apply a teacher-centred method of teaching. On the other hand, if the teacher sees mathematics as a procedural process of expanding the field of human creation and innovation, he/she will request active participation of students and will focus on problem solving and a student-centred approach in order to develop students' understanding (Ernest 1989).

Research findings from a number of studies have shown that teachers' instructional practices do reflect the kind of perspective they have of the subject (e.g. Jurdak 1991; Teo 1997; Stigler and Hiebert 1999; Pepin 1999; Mereku 2003; Perkkila 2003; Handal and Herrington 2003). Jurdak (1991), in his research on mathematics teachers, reveals that "the conceptions of the foundations of mathematics are more related to teaching behaviours than to self reported conceptions of mathematics which normally reflect the expectations of what constitutes 'good' teaching" (p. 228). In other words, the kind of viewpoint that the individual has developed over time has a greater influence on teaching behaviours than the conceptions that the person has developed as a result of reforms and other training programmes.

In addition to this, Teo (1997) investigated the beliefs of 16 teachers in Singapore and the study reveals that all the teachers except one indicated their awareness that their beliefs and conceptions about mathematics had influenced their teaching methods. Pepin (1999), in his study of the conception and work of mathematics involving three European countries: England, France and Germany, also shows that teachers' perspectives are reflected in their teaching practices. In other words, teachers teach in a way that they conceive the subject and that reflects how they themselves were taught. Perkkila (2003), in his studies involving Finnish primary school teachers, also outlines that teachers' recollections of their experiences (e.g. difficulties with mathematics learning) had a great influence on their teaching practices and the way in which a teacher teaches can be traced back to his/her school days.

Mereku (2003) finds that, despite the uniformity of the mathematics curriculum in Ghana, the implementation and adaptation of this school curriculum and its associated teaching methods and learning strategies has not been the same in all classrooms. Mereku further explains that, teachers use different teaching methods and, in most cases, these methods were not consistent with the national curriculum guidelines. It was established that the implementation of the school curriculum at the classroom level is a function of the individual teacher's decisions and conceptions relating to his/her understanding of the subject matter. Mereku adds that no matter what the instructional practices documented in the national curriculum, the teacher's approach to the subject will have an impact on the teacher's teaching. He concludes that a teacher's beliefs and perspectives of the subject play an important role in translating the formal curricular into specific instructional practices. Similarly, Handal and Herrington (2003) add that a "successful curriculum change is most likely to occur when the curricular reform goals relating to teachers' practice take account of teachers' beliefs" (p. 65). These empirical findings suggest that there is a direct relationship between teachers' beliefs and the way they teach.

However, contrary to the findings from the above studies, a number of other researchers have found some inconsistencies (e.g. Stigler and Hiebert 1999; Li and Yu 2010). Stigler and Hiebert (1999) disclose that most teachers, among teachers who normally express non-traditional beliefs, display inconsistent practices and, although all the teachers in their study reported that they held non-traditional beliefs, their actual teaching practices were inconsistent with these beliefs. Perkkila (2003) also finds that teachers' beliefs about mathematics were primarily non-traditional, but their instructional practices still focused on textbooks, rules and procedures in solving problems. Li and Yu (2010), who studied the relationship between a pre-service teacher's beliefs about mathematics and his/her teaching practices, divulge some inconsistencies between the teacher's beliefs and his teaching practices. They attribute these inconsistencies to a lack of pedagogical content knowledge about mathematics teaching.

In general, teachers' beliefs about mathematics play an important role in their teaching and understanding these beliefs provides important information to help comprehend why teachers' teach the way they do. It is clear from the literature that the stated beliefs of a majority of teachers conform to the principles of constructivism. However, most of these teachers make surface changes to their teaching by adopting some of the more easily assimilated practices into their pedagogical repertoire as it is easier for them to adopt practices that match their beliefs (Windschilt 2002).

5.4 Teachers' Subject Content and Pedagogical Knowledge

Despite the importance of a teacher's beliefs and perspectives in shaping his/her teaching practices, teachers' knowledge of mathematics has been an issue of concern for some time now, which is documented in a number of research documents (e.g. Ball 1991; Aubrey 1997; Davis and Simmt 2006; Turnuklu and Yesildere 2007). According to Ball (1991), teachers' subject content knowledge influences the way they teach. Teachers cannot help children when they themselves do not know the subject. Aubrey (1997, p.3) argues that, if teaching involves helping others to learn, then understanding the subject content to be taught is a fundamental requirement of teaching. From the viewpoint of Selden and Selden (1997), the way the teacher teaches depends to a large extent on their conceptual grasp of the subject content knowledge that they acquire during their college and teacher training classes.

A number of studies have examined the impact of teachers' subject content knowledge on their teaching, with contrasting findings. Bennett and Turner-Bisset (1993) discovered that teachers' subject content knowledge has a direct relationship with their teaching. They add that a thorough understanding of the mathematical concepts that the teacher teaches is necessary for effective teaching and learning. Turnuklu and Yesildere (2007) also reveal that the individual teacher's ability to promote effective teaching and learning processes in their classroom is influenced by their conceptual understanding of mathematics. They add that students would learn more mathematics if their teachers knew more mathematics.

However, in Mewborn's opinion (2001), although mathematics teachers' subject content knowledge plays an important role in the teaching-learning process, "merely knowing more mathematics does not ensure that one can teach it in ways that enable students to develop deep conceptual understanding" (p.28). Sung-Tao and Huann-Shyang (2005) also argue that, although adequate content knowledge of the subject matter is a requirement for teaching, knowledge itself is not a promise of suitable instruction. A teacher may be very good in his/her subject area, but may find difficulty in delivering this knowledge in his/her classroom.

Research by Mewborn (2001) shows that, while the overwhelming majority of teachers have command of the facts and algorithms of school mathematics, most of these teachers lack the conceptual understanding of the mathematics they are expected to teach. Similarly, Asiedu-Addo and Yidana (2004) also suggest that, although research has shown that there is a direct relationship between content knowledge and students' performance, it is still not clear whether teachers' content knowledge alone is enough to promote effective teaching and learning.

In general, the individual teacher's subject content knowledge plays an important role in the way he or she delivers a particular topic. However, possessing sufficient or good subject knowledge is not enough to promote effective teaching and learning (Even 1993). An *et al.* (2004) argue that good mathematics knowledge, together with a grasp of how to teach mathematics (pedagogical knowledge), can result in effective teaching and learning. They add that "pedagogical content knowledge", which includes familiarity with the mathematics curriculum and knowledge of teaching, can together promote effective teaching and learning. Knowledge of the curriculum can include selecting and using suitable curriculum materials to enhance students' understanding and learning, while knowledge of teaching consists of knowing how students think and preparing instructions (An *et al. 2004*). Even (1993) also defines Pedagogical Content Knowledge as "knowing the ways of representing and formulating the subject matter that makes it comprehensible to students as well as understanding what makes learning of specific topics easy or difficult" (p.94).

From the above discussions, it can be concluded that possession of sound subject content knowledge is a requirement for teaching. However, content knowledge alone does not necessarily promote effective teaching and learning; knowing how to teach and possessing the requisite subject content knowledge is a requirement for every teacher to ensure effective teaching and learning. However, the way a teacher teaches and how a teacher interprets or perceives his/her teaching can be influenced by the guidelines and requirements of the national curriculum and its accompanying syllabus.

5.5 Teachers' Perceptions of their Teaching and the Curriculum

Richards (1998) claims that:

> While teachers' belief systems shape the way they understand teaching and the priorities they accord to different dimensions of teaching, the thinking that teachers employ during the teaching process itself is also crucial to our understanding of the nature of teaching skills (p.73).

It is only possible to understand how and why a teacher teaches in a particular way by understanding how the teacher interprets his/her teaching practices. Ahmad and Aziz (2009, p.19) suggest that teachers' perception of their teaching and learning situations are important, as they reinforce teachers' decision-making about how to handle classroom situations. How the teacher perceives his own teaching is also important in understanding how he/she will present or teach the subject.

In line with the theoretical perspectives discussed in Chapter 3 and 4, two categories of approach are distinguishable in the literature: behaviourism and constructivism. Although the relationship between teachers' thinking and their teaching practices is not necessarily straightforward, recent reforms support constructivist principles of teaching and learning. Accordingly, it can be confirmed that teachers' perceptions of their teaching are influenced by the curriculum recommendations. According to Smith (III 1996), teachers' perceptions of their teaching practices have always supported constructivist ideas and principles, although their actual teaching practices may vary or completely differ from the underlining principles of constructivism.

Macnab and Payne (2003) believe that mathematics teachers are confident and have strong personal views when it comes to their perception and interpretation of their teaching practices. They opine that, although the results from their questionnaire show that teachers perceive their teaching as student-centred, classroom observations revealed that most of these teachers were unadventurous in their own teaching and used approaches contrary to their own interpretations. Keskitalo (2011) also reveals that teachers widely interpret their role as facilitators of students' learning, with their teaching being underlined by the principles of constructivism as documented in most mathematics curricula.

In general, teachers' opinions of their teaching are an important tool for measuring individual teaching styles. However, teachers' interpretations or perceptions of their teaching are influenced by the content of the national curriculum and associated initial training and continuing professional development. Many teachers interpret their teaching practices to concur with the ideas documented in the national curriculum. Using teachers' interpretations of their own teaching as the basis for examining or measuring teachers' teaching practices has therefore been greatly criticised in the literature because of the numerous inconsistencies. Ahmed and Aziz (2009) aver that collecting data from students regarding their teachers' teaching provides a meaningful snapshot of what their teacher does, as their perceptions are "coloured by challenging and interesting experiences that allow them to observe learning and teaching behaviours more intimately" than their teachers (p. 19).

5.6 Students' Learning and Personal Characteristics

Students' learning and construction of new knowledge is influenced by a number of factors; however, research evidence suggests that the way students learn and construct new knowledge is greatly influenced by the individual student's personal characteristics. These characteristics include the individual student's ability, motivation, effort, attitude and self confidence toward the learning of mathematics. For the purpose of this study, students' personal characteristics are limited to the kind of attitudes and perceptions that they have towards mathematics. Aronson *et al.* (1997) suggest that:

> "….attitudes are made up of affective components consisting of your emotional reactions toward the attitude object (e.g. another person or a social issue); a cognitive component consisting of your thoughts and beliefs about the attitude object; and a behavioural component, consisting of your actions or observable behaviour toward the object" (p. 229).

Students' conceptions of themselves as learners are strongly connected with the kind of general attitudes and perceptions they display towards the subject in question (Schoenfeld 1992; Dochy *et al.* 1996). Dochy *et al.* (1996) explain that students' prior knowledge shapes their learning experiences and the acquisition of new knowledge is dependent on the individual learner's prior knowledge, which is shaped by their conceptions. According to Dochy *et al.* (1996), new knowledge is difficult to construct when prior knowledge is not used as a springboard for future or further learning.

According to Singh *et al.* (2002, p.324), “attitudinal and affective variables such as self-concepts, confidence in learning mathematics…interests and motivation have emerged as salient predictors of achievement in mathematics”. They add that these factors also, to some extent, predict students’ avoidance of mathematics and science related subjects at the higher level of the academic ladder. I have argued elsewhere (Ampadu 2009) that, students enjoy extending their learning from familiarity with a particular concept to knowing why that concept exists and its application; this comes into play when they acknowledge the utilitarian benefits they will derive from understanding the concept. It is only when students acknowledge the importance of mathematics as a subject and how it will help them in their daily lives that their affective characteristics can be changed. That is, based on the general perception that mathematics is the most difficult subject, students will continue to show negative attitudes towards it until they have identified the importance of what they are learning (Ampadu 2009).

Lampert (1990), in his research on ‘knowing and teaching’, identifies that many students appear to hold naive and incorrect beliefs about mathematics and sometimes see the subject as being meant for a particular group (the so called ‘brainy’). Lampert further reveals that, when this happens, it creates a gap in the midst of preparing people for the era of information technology (Lampert, 1990). Singh *et al.* (2002), in their findings on ‘mathematics and science achievement’, also confirm a direct relationship between students’ attitudes and their learning. Prosser *et al.* (2003) observe that students who perceive the learning of mathematics as a set of computational skills are more likely to adopt a surface approach to learning. Those who perceive mathematics as the learning of concepts and recognise its application to real life situations study the subject by employing a deeper learning approach which is associated with a higher quality and quantity of understanding.

Research by Singh *et al.* (2002) shows that affective and perceptual factors can be very difficult to change because they are formed by social forces such as society's perception of and attitude towards the subject. Singh *et al.* (2002) therefore argue that it is possible to enhance these affective factors by providing modified and innovative curricular and instructional approaches that conceptualise and create meaning and emphasise the relevance of the subject in the teaching and learning process. They add that when students are made aware of the importance of mathematics in their future endeavours and careers, together with the opportunities that await them if they excel in mathematics, they may change their attitudes and perceptions toward the subject. In general, although the kind of perceptions that students possess is dependent upon their personal experiences, which are difficult to change, providing students with innovative instructional and learning strategies can also help to change the incorrect fallacies that students may have developed about the subject (Singh *et al.* 2002).

5.7 The Classroom Environment and Students' Learning

Although students' personal characteristics have a significant influence on their learning experiences, in the school the core of the interplay between the learner/student and what is learnt is accredited to the teacher (Ampadu 2010). Teachers are, and will continue to be, one of the most important educational influences on students' learning in general and mathematics in particular (Hanna and Nyhof-Young 1995). A NCTM (2000) report provides evidence of alignment between students' learning experiences and their teachers' teaching practices. The report points out that:

> Students learn mathematics through the experiences that teachers provide. Thus, students' understanding of mathematics, their ability to use it to solve problems, and their confidence in, and disposition toward, mathematics are all shaped by the teaching they encounter in school. The improvement of mathematics education for all students requires effective mathematics teaching in all classrooms (p. 17).

Even though most students do spend the largest part of the day in their respective homes with parents and siblings, the few hours they spend at school have a great influence on their lives and their construction of new knowledge (Hanna and Nyhof-Young 1995). That is; the classroom environment helps students extend their learning and the different experiences they have gained from home. The application of these experiences in solving real life problems depends on the nature of the classroom learning environment (Hanna and Nyhof-Young 1995; Ampadu 2010). Teachers' actions are what encourage students to think and discuss their ideas and this puts pressure on teachers as they try to create intellectual environment that will help students acquire mathematical knowledge (Singh *et al.* 2002). That is, teachers play an important role in the teaching and learning process and the way the teacher communicates his/her ideas and viewpoints to students influences how the individual student learns (Turnuklu and Yesildere 2007). The individual experiences that students bring to the classroom is therefore developed or marred by the quality of the learning environment which is nurtured by the teacher (Singh *et al.* 2002).

It is thus confirmed that there is a direct relationship between teachers' teaching practices and the learning experiences of students. Martin and Ramsden (1998), in their study involving six teachers, establish a direct relationship between teachers' descriptions of their teaching and students' descriptions of their learning strategies. Students reported adopting a deeper learning approach when they described their teachers' teaching as good, which helped them to develop a conceptual understanding of the concepts and skills presented. Trigwell *et al.* (1999) discovered that qualitatively different approaches to mathematics teaching are associated with qualitatively different learning approaches. They reveal that teachers who conceive teaching as the process of transmitting information to students adopt a teacher-centred approach and students learn by imitation or memorisation of formulae. On the other hand, teachers who conceive learning as developing and changing students' conceptions adopt a student-centred approach whereby students are encouraged to construct their own knowledge by exploring their immediate world.

In general, students' learning experiences and the way new knowledge is constructed are determined by how a mathematical concept is presented to the students. As in most parts of the world, the mathematics curriculum in Ghana explicitly outlines the teaching and learning strategies to be used when teaching a particular topic in mathematics and the required textbooks (MoE 2007). However, the transition from theory to practice continues to be one of the major issues challenging progress in most mathematics classrooms. For example, Anamuah-Mensah *et al.* (2004) disclose that only 42 percent of Ghanaian junior high school mathematics teachers use mathematics textbooks as the main basis for lessons, while 54 percent use them as a supplement. They further add that most mathematics teachers use a teacher-centred approach to teaching, where students passively construct new knowledge.

In addition to the impact of human factors on the teaching and learning of the subject, the way teachers teach and how students learn is to a large extent affected by the physical learning environment. According to Murillo and Roman (2011),

> Improving the quality of education requires relevant and high-quality physical conditions and educational resources to allow for efficient teaching and learning processes.…the learning opportunities of students who attend schools where there are no didactic resources available or where there is a low level of teaching resources are significantly reduced or constrained (p. 46).

Murillo and Roman (2011) define the schools' physical environments as offering basic services and physical facilities (potable water, electric supply, sewage services). For the purposes of this study, the physical learning environment is limited to classroom resources and other teaching-learning materials within the classroom, as the focus of the present study is the classroom.

The relationship between teaching and learning resources and students' personal experiences is well established in the literature. According to Fisher (2000), favourable physical environments provide favourable learning conditions for students and promote effective learning. Mji and Makgato

(2006) also agree that most students who perform poorly are from schools which lack the facilities and resources necessary for enhancing effective teaching and learning in our schools.

The provision of adequate teaching and learning materials has therefore become an issue of major concern; the textbook is considered to be the most important item of teaching material by the teachers and policy makers (Vincent and Stacey 2008). In most junior high schools, the textbook constitutes the main source of teaching and learning material and many teachers rely on the textbook as their main instructional material in their lessons; some teachers may supplement this resource with other materials (Vincent and Stacey 2008). According to Rezat (2009), mathematics textbooks form an integral part of students' learning and there is a direct relationship between the quality and quantity of mathematics textbooks and students' learning experiences. Henningsen and Stein (1997) argue that:

> The tasks in which students engage provide the contexts in which they learn to think about subject matter, and different tasks may place different cognitive demands on students …. Thus, the nature of tasks can potentially influence and structure the way students think and can serve to limit or to broaden their views of their subject matter with which they are engaged. Students develop their sense of what it means to "do mathematics" from their actual experiences with mathematics and their primary opportunities to experience mathematics as a discipline are seated in the classroom activities in which they engage … (p.525).

Students use textbooks in different ways and this varies according to their beliefs and perceptions of the subject. Rezat (2009) explains that students use textbooks to solve tasks and problems, consolidate knowledge, acquire mathematical knowledge and aid activities, and they are associated with an interest in mathematics. In general, teachers and students use the textbook as a tool to promote effective teaching and learning; it also helps students to make connections to real life situations and different applications. Studying multiple presentations of mathematical phenomena is one way that students can develop a much richer understanding of mathematics.

According to the NCTM (2000) report, one way to present multiple varieties of mathematical concepts is to use instructional materials that are intentionally designed to weave together different content strands. However, despite the importance of the textbook in promoting effective teaching and learning, it has become a written lesson protocol for many students as they rely on it for their main source of reading material (Vincent and Stacey 2008). Vincent and Stacey further argue that over-reliance on textbooks during lessons leads to routine use of procedures, which does not promote deeper learning among students.

5.8 Framework for Analysing Mathematics Lessons

From the above discussions, it is important to note that the teaching and learning of mathematics is influenced by a number of different factors. Understanding the complex classroom discourse therefore requires an understanding of the different, but interrelated elements discussed above. Therefore, comprehending these issues and how they have been informed by the paradigm shifts in mathematics teaching and learning leads to an insight into the environment of the mathematics classroom.

The changes in mathematics teaching and learning over the years have influenced the way that the subject is taught and learned and, at the same time, brought about modifications within the research methodologies in the field (Nickson 2000). The most obvious adjustment has been a gradual swing from quantitative research to more qualitative research, as well as a combination of both qualitative and quantitative methods when investigating classroom practices (Nickson 2000).

In order to explore the differences that exist between the different frameworks for analysing mathematics lessons, this section will consider the three frameworks that can be used to analyse mathematics lessons, as proposed by Koehler and Grouws (1992), who claim that the first level of research examines classroom teaching by focusing on teacher effectiveness. At this level, specific teacher characteristics are studied in isolation and quantitative data is collected to understand how these factors hinder or promote effective teaching and learning of mathematics. The framework at this level of classroom teaching and learning analysis could be linked to the behaviourist theory, in the sense that much of the emphasis in the classroom is on the teacher. From the behaviourist point of view, the teacher is considered to be an important factor in students' learning and knowledge acquisition. The teacher is said to have failed if his/her students are not able to reproduce the knowledge he has imparted or perform well in both national and international examinations (Nickson 2000).

Thus, in general, at this level classroom teaching and learning is analysed based on a teacher's characteristics and ability. One of the main advantages of studies at this level is the fact that they produce statistical data that could be used to generalise to a wider population. However, they have been criticised for not providing acceptable ways of analysing the teaching and learning of mathematics, as they neglect other factors that affect teaching and learning. Critics of this approach have also argued that this approach fails to distinguish people and social institutions from the world of nature, and the findings from such research do not provide an in-depth analysis of the phenomenon under consideration (Patton 1990; Yin 2003).

The second framework for analysing mathematics teaching and learning consists of multiple classroom observations, which represents a move from the gathering of quantitative data to the collection of qualitative data. Such studies particularly focus on classroom processes to understand what goes on in the classroom without necessarily understanding what teachers and students think they do in their respective classrooms. This approach is used to study students' and teachers' behaviour in the classroom and the central feature "is a careful documentation of what teachers and students do during mathematics instruction" (Koehler and Grouws 1992, p. 116). This approach to analysing mathematics teaching and learning places emphasis on identifying both teachers' and students' behavioural traits which influence classroom practices. It also examines the effects of the classroom environment on teaching and learning, to pick up on some of the characteristics of the constructivist theory of teaching and learning. In general, researchers with this theoretical perspective use qualitative instruments and data analysis procedures in order to provide in-depth and detailed examination of the problem under investigation, which may not be attained when using a quantitative approach.

The third framework for analysing mathematics teaching and learning consists of collecting different sets of data in order to understand what happens in classrooms, as well as establishing what factors affect mathematics teaching and learning. Koehler and Grouws (1992) describe this approach as having a wide-ranging effect on all the participants in the mathematics classroom, rather than isolating the effects of the teacher or students, as seen in levels one and two. This method examines the teaching and learning of mathematics from different perspectives, each emphasising different levels of participation among students and the role of the teacher in the teaching-learning process. In general, this approach embraces features associated with ideas from both behaviourist and constructivist worldviews when investigating a given problem in the field of mathematics teaching and learning. However, this approach rejects the "dogmatic either-or choice between constructivism and post positivism and the search for practical answers to questions that intrigue the investigator" (Tashakkori and Teddlie, 2009, p. 86).

5.9 Reconsidering the Theoretical Models

As discussed above, two theoretical orientations toward the teaching and learning of mathematics have generated great interest and have informed effective instructional practices. Table 5.1 summarises the key features of the behaviourist and constructivist perspectives of teaching and learning, highlighting the differences.

Table 5. 1: Comparisons of Behaviourist and Constructivist Perspectives

	Behaviourist Perspective	**Constructivist Perspective**
Pedagogy	Transmission approach, teacher-centred, teachers present knowledge	Learner-centred, students discover and construct knowledge
Knowledge Acquisition	Knowledge is acquired Receptive	Knowledge is created Discover and construct new knowledge
Assessment	External Standards Summative Tests	Individual Standards Formative Tests
Role of the teacher	Teacher structures learning task Teacher provides resources Teacher dominates the teaching-learning process Teacher demonstrates Reactive teachers	Teacher structures the environment Teacher guides students to find resources Teacher observes and facilitates in the teaching-learning process Social interaction structures learning Proactive teachers
Role of the learner	Learner as memoriser Learner methods Learn facts Individual learning	Learner as a processor Develop learning strategies Create meaning Cooperative learning
Research	Theory testing Objective	Theory emergent Subjective

Source: Hofstetter (1997)

Throughout the 1970s and early 1980s, behaviourist approaches to teaching and learning influenced the teaching and learning of mathematics in Ghana (Mereku 2003). However because of the numerous limitations associated with behaviourism, constructivism has dominated the teaching and learning of mathematics for the past three decades (Boaler 2009). Constructivism has contributed a reframing of the teacher as a facilitator or a guide, in contrast to the teacher being someone who tells or gives information to the learner (Proulx 2009). Empirical research in relation to mathematics teaching and learning has therefore favoured the ideas of constructivism and suggests that students need to be given some autonomy and control over their own learning. Based upon these theoretical assumptions, the mathematics curriculum in Ghana, similar to most other countries, has undergone immense changes since the late 1980s, with the introduction of the new mathematics syllabus underpinned by the principles of constructivism (MoESS 2007).

While the suitability of the behaviourist approaches to teaching and learning has been questioned (Westwood 1999), deciding on appropriate strategies for the teaching and learning of mathematics has been an issue of much concern due to the limitations of the two main theoretical perspectives. Westford (1999) further argues that, just like behaviourism, constructivist approaches to teaching and learning cannot guarantee students will acquire fluency and automaticity with basic number and computation. Like all other mathematics curricula, the new mathematics curriculum in Ghana provides different teaching and learning methods that should be used and these strategies are based on the principles of constructivism (MoESS 2007; Chambers 2008). However, as previously indicated (see Chapter 2), the objectives and guidelines of the new curriculum do not fully adhere to the principles of constructivism.

According to Conney (1988):

> Both mathematicians and mathematics educators cannot escape their responsibility for shaping their students' philosophies of mathematics no matter how implicitly or subtly those philosophies may be communicated by their instructional methods, the means by which they encourage students to learn mathematics and the means by which they assess their students learning of mathematics (p. 359).

In a similar vein, Sfard (1998) states that "because no two students have the same needs and no two teachers arrive at their best performance in the same way, theoretical exclusivity and didactic single-mindedness can be trusted to make even the best educational ideas fail" (p.11). The above discussions and quotations suggest that the two main theoretical perspectives discussed have much to contribute in terms of enhancing our understanding of teaching and learning, although neither is entirely appropriate under all circumstances (Chowdhury and College 2006). Behaviourism is considered appropriate for the teaching and learning of methods and algorithms, but does not promote critical thinking among students. Constructivism, on the other hand, encourages students' active participation in the teaching and learning process by giving the opportunity to create and develop their own knowledge through exploring the environment via investigative approaches. However, as discussed in Chapter 4, the application of genuine constructivism in classrooms can be problematic, as constructivism does not explicitly provide teaching methods to be used by teachers.

Looking Beyond Behaviourism and Constructivism –Introducing Enactivism

Considering the criticisms associated with behaviourism and constructivism and the gaps in the new national curriculum for Ghana, it is argued that no one particular theoretical perspective can facilitate the effective teaching and learning of mathematics. The theoretical perspectives of behaviourism and constructivism introduce the possibility of researching mathematics teaching and learning by combining different theoretical perspectives. The teaching and learning of mathematics, therefore, goes beyond the ideas of the dichotomies of behaviourism and constructivism and creates a need to consider an alternative framework for understanding how mathematics is taught and learned, or should be taught and learned, in Ghanaian Junior Secondary Schools. For these reasons, instead of focusing on one theoretical perspective, I employ a conceptual framework that finds a middle way between the two extremes by drawing from the principles of both behaviourism and constructivism helping order to encourage effective teaching and learning.

The conceptual framework that guides the collection, interpretation and the entire research process is based on the belief that learning is a shared activity between the learner and the teacher, but the role of the teacher is more than a mere facilitator. The principal feature of this framework is the fact that the way in which mathematics is taught and learned is related and can only be understood by investigating the phenomenon from different theoretical and methodological perspectives. To achieve this, teachers' and students' perceptions of their classroom practices, as well as what they actually do in the classroom, will be examined using both quantitative and qualitative data collection and analysis procedures. The conceptual framework chosen for this study therefore combines behaviourist and constructivist strategies, since a combination of strategies from these different but interrelated perspectives is considered to be more effective than either single perspective (Westwood 1999).

This framework is consistent with Dewey's pragmatist philosophy of education, which suggests that teachers and students ought to work together as investigators in the classroom to create new knowledge (Dewey 1930/1984b). According to Dewey (1929), the teacher's role is not to "impose certain ideas or to form certain habits in the child, but...to select the influences which shall affect the child and to assist him in properly responding to these influences" (p. 9). He therefore advocates a teaching method in which teachers and students both participate in educational experiences and the teacher is classified as a natural leader in shared activity because of his/her greater maturity and wider knowledge (Dewey 1930/1984b, p.322). This suggests that the teacher does not only acts as a facilitator in the teaching and learning process, but also as a partner who is actively involved in the creation and acquisition of new knowledge in the classroom.

Dewey's ideas regarding the teaching and learning process, the role of the teacher and that of the student in the classroom have, for the past decade, been conceptualised into a new philosophy of pedagogy known as enactivism (Li, 2008). Enactivism is compatible with elements of Piaget's and Vygotsky's constructivist psychology and is based on the belief that "cognition and environment are inseparable and 'systems' enact with each other from which they learn" (Li 2008, p.3). The central idea of enactivism is based on the premise that learners and teachers or educators are co-authors and the classroom discourse is a two way affair and considers the individual as not simply an observer of the world, but as embedded in the world (Davies *et al.* 2000; Reid *et al.* 2000).

Begg (2002) and Proulx (2009) advocate the adaptation of the enactivist theory in mathematics classrooms because of the complex nature of mathematics teaching and learning, which cannot be examined using only one particular theory or research strategy. Learning affects the entire psyche of the individual and this goes beyond cognitive knowing, as emphasised in the constructivist theory which is now the theoretical underpinning of the Ghanaian mathematics curricula. While the new mathematics curriculum does not use the term enactivism, the ideas and guidelines presented are more consistent with the principles of enactivism than those of constructivism. Begg (2002) describes enactivism as an ecological theory that can be considered to be an alternative premise to constructivism. He further adds that those who hold this theoretical perspective see learning as a shared activity between the learner and the teacher. Davis *et al.* (1996) define enactivism as an embodied experience with patterns that shape the individual learner's learning and the creation of new knowledge. In a similar vein, Reid et al. (2000, pp. 1-10) agree that enactivism, like social constructivism, acknowledges the "importance of the individual in the construction of a lived world, but emphasises that the structure of the individual coemerges with this world in the course of, and as a requirement for, the continuing inter-action of the individual and the situation". This suggests that the understanding of the individual and how he/she creates or acquires new knowledge is based on schemes of bodily movement and its perceptions (Begg 2002).

Even though constructivism and enactivism may share some seemingly parallel aspects, they are two fundamentally different theoretical perspectives. For example, both theories consider the environment to play a vital role in knowledge creation and acquisition. Constructivists believe that:

> Humans actively construct their own meanings of situations; meaning arises out of social situations and it is handled through interpretive processes; behaviour and, thereby, data are socially situated, context related, context dependent and context-rich (Cohen *et al. 2004,* p.137).

However, although knowledge is private and belongs to the individual, this private knowledge can only be developed through continuing interactions of the individual learner and the environment (Saetler 1990). "Enactivism as a theory of cognition acknowledges the importance of the individual in the construction of a lived world, but emphasizes that the structure of the individual co-emerges with this world in the course of, and as a requirement for, the continuing inter-action of the individual and the situation" (Reid *et al.* 2000, pp.1-10).

The core component of enactivism exemplifies the belief that "the human mind is embodied in our entire organism and embedded in the world, and hence is not reducible to structures inside the head" (Thompson 2005, p. 408). Enactivism emphasises the fact that the creation of knowledge and the understanding of the world is a shared activity through different systems in order to build a holistic picture of the phenomenon (Sumara and Davis 1997; Li 2008). From an enactivist perspective, the changes in how mathematics is taught and learned are based on the beliefs that learning is "a participation in the world; a co-evolution of the knower and known that transforms both" (Davis *et al.* 2000; p.64). Classroom practices envisioned by enactivism therefore differ from either the 'adult-run' which is associated with behaviourism or 'children-run' instruction which is associated with constructivism (Rogoff, 1994, p.210). Learning is not just about gaining information, but is an ongoing process of exploration and interactions with complex systems in order to adapt to the evolving environment (Li *et al*. 2010). The act of knowing depends upon "the kinds of experience that come from having a particular body plan, schema, or system with a variety of neuronal-sensorimotor abilities, capacities, and functions" (Thompson 1996, p. 128).

In enactivism, learning occurs when individuals act and interact with each other, changing their behaviour by developing and creating new knowledge together and learning from each other. This suggests that in an enactivist classroom the teacher does not seek to facilitate nor direct the pupils in what to do and think, but promotes participation and genuine interaction to encourage learning (Proulx 2009, p.275). Teachers are not the source of knowledge in the classroom, but co-author knowledge with students by guiding students' attention towards the intended goals (Li *et al.* 2010). According to Proulx (2009), in the enactivist classroom teachers and students work together to bring forth a world of understanding and this common goal cannot be achieved if the teacher acts as a mere facilitator as proposed by those with a constructivist world view. The role of the teacher is more than that of a mere facilitator, as his/her actions are considered to be triggers for students' learning and this is compatible with a typical classroom situation (Proulx 2009).

This "calls for a teacher that puts oneself within the action and acts vigorously in this learning space to trigger and provoke something in learners" (Proulx 2009, p. 273). The teacher's active participation in the teaching and learning process is paramount, as there are still some mathematical concepts that the student cannot learn alone and the assistance of a teacher to trigger the students' learning is necessary (Mathews 1997). The implementation of a real cooperative learning approach, as suggested by constructivist theory, becomes problematic if the teacher doesn't actively take part and sometimes lead the process (Gillies, 2003). Gillies adds that the implementation of cooperative learning strategies, one of the principles of constructivism, is sometime problematic as just putting people in groups does not necessarily lead to effective learning. He further argues that structured cooperative learning that can lead to better learning outcomes and it is only when the teacher structures these groups in such a way as to ensure students understand how they must work that the desired results can be achieved.

Enactivism as a methodology is a theory for learning which follows the belief that a research process needs to take place from multiple perspectives in order to provide a holistic understanding of the phenomenon (Cole 2007; Reid 1996). The enactivist researcher cannot separate him/her self from his/her personal experiences and what he or she perceives. The enactivist approach is therefore based on the belief that reality is a given but "perceiver-dependant, not because the perceiver constructs it as he or she pleases, but because what counts as relevant world is not separable from the structure of the perceiver" (Varela 1999, p. 13). Begg (2000) agrees with this view, that to be able to make sense of what happens in a mathematics classroom one needs a framework which provides a holistic view of the teaching and learning of mathematics through the use of multiple perspectives. An enactivist approach to research includes objectivism and subjectivism and therefore employs both quantitative and qualitative research methodologies to collect and analyse data. It is concluded that, although quantitative and qualitative approaches to research have some validity, investigating a research problem from different perspectives results in a deeper understanding of the problem under consideration.

Table 5.2: Comparisons of Behaviourist, Enactivist and Constructivist Perspectives

	Behaviourist Perspective	**Enactivist Perspective**	**Constructivist Perspective**
Pedagogy	Transmission approach, teacher-centred, teachers present knowledge	Group centred instruction Embodied	Learner-centred, students discover and construct knowledge
Knowledge Acquisition	Knowledge is acquired Receptive	Knowledge is adopted Knowledge is enacted	Knowledge is created Discover and construct new knowledge
Assessment	External standards Summative tests	Summative tests Formative tests	Individual standards Formative tests
Role of the Teacher	Teacher structures learning tasks Teacher provides resources Teacher dominates the teaching-learning process Teacher demonstrates Reactive teachers	Collaborator Actively guides learning Active participant in the teaching-learning process Guide students towards co-evolving patterns Provide rich learning activities	Teacher structures the environment Teacher guides students to find resources Teacher observes and facilitates in the teaching and learning process Social interactions structure learning Proactive teachers
Role of the Learner	Learner as memoriser Learner methods Learn facts Individual learning	Individual learning Create meaning Actors	Learner as a processor Develop learning strategies Create meaning Cooperative learning
Research	Theory Testing Objective	Objective Subjective	Theory Emergent Subjective

5.10 Summary

This chapter has discussed the fact that two learning theories are distinguishable in the literature and these theories involve different teaching and learning strategies. One of the key issues raised is the fact that, although knowledge is private to the individual learner, the learner creates his/her own conception of this knowledge through interaction with others and the environment.

Another key issue discussed in this chapter is the fact that classroom activities are related, that learning affects the entire psyche and that the teaching and learning of mathematics goes beyond the ideas of behaviourism or constructivism. Dewey's pragmatic approach to the role of the teacher and the student in classroom discourse, which has recently been conceptualised into the theoretical perspective of enactivism, underpins the conceptual framework for the present study. The framework therefore combines different, but interrelated theoretical perspectives when seeking to understand the mathematics classroom discourse. Likewise, the analysis of mathematics lessons requires multiple approaches to thoroughly illuminate the phenomenon under investigation. Chapter 5 has set the agenda for Chapter 6 and thus the methodology of the study is discussed in the next chapter.

PART III: METHODOLOGY AND METHODS

Chapter 6

Methodology

6.1 Introduction

The purpose of this research is to investigate the teaching and learning of mathematics in Ghanaian junior high schools. The main components of this study are the teaching strategies adopted in mathematics classrooms and students' experiences of being taught mathematics. The research questions that the research seeks to answer are as follows:

1. What teaching methods are used by mathematics teachers?
2. Why do mathematics teachers use these teaching methods?
3. Is there any relationship between teachers' perception of their classroom practices and what they actually do in class?
4. What are students' perceptions of their teachers' teaching practices?
5. What are students' experiences of being taught mathematics?

This chapter discusses the research design, the strategy chosen for conducting the research, the data collection and analysis procedures and the sample and sampling techniques used. The chapter also reveals how the study site and the participants for the study were selected. Finally, the strategies used to evaluate the validity and reliability of the research instruments and the trustworthiness of the research process and the results, as well as the anticipated ethical issues, are also explored in this chapter.

6.2 The Research Methodology

This study draws upon the enactivist world view and the ideas of Dewey (1983) and Begg (2002) in understanding the teaching and learning of mathematics. This approach suggests that classroom discourse is complex and cannot be investigated from any single theoretical perspective. Just as behaviourism and constructivism have been criticised for undermining how classroom activities are related since learning affects the entire psyche, the limitations of both quantitative and qualitative research paradigms have been an issue of concern.

The usefulness of combining both quantitative and qualitative research techniques is well documented in the literature. Clarke (2002) argues that the social settings within which research is conducted are normally multiply constructed, which calls for the employment of a research methodology that offers a voice to the numerous participants in the setting and avoids the authority of any one voice. Silver (2004) suggests that devising a framework to investigate mathematics teaching requires the generation of a holistic approach that combines quantitative and qualitative approaches as a deliberative process for the examination of and inquiry into a research problem.

There are several reasons for using a mixed-methods research design to investigate a research problem. Patton (1990) believes that some researchers use mixed-methods to achieve convergence across quantitative and qualitative methods to better understand the phenomenon under consideration by integrating diverse explanations from the varied methods. Hason *et al.* (2005:224) suggest that, in most cases, researchers use both quantitative and qualitative methods in a single study in order to simultaneously generalise results from a sample to a population and also gain a deeper understanding of the phenomenon. Gay *et al.* (2006) also report that the purpose of conducting mixed methods research is to “build on the synergy and strength that exists between quantitative and qualitative research methods in order to understand the phenomenon more fully than is possible using either quantitative or qualitative methods alone" (p.490).

Denscombe (2008: 272) identifies five motives for using a mixed methods approach: (a) some researchers use mixed methods to improve the accuracy of their data, (b) others use mixed methods to produce a more complete picture by combining information from complementary kinds of data or sources, (c) mixed methods are used as a means of avoiding biases intrinsic to single-method approaches as a way of compensating for specific strengths and weaknesses associated with particular methods, (d) mixed methods are used as a way of developing the analysis and building on initial findings using contrasting kinds of data or methods, (e) mixed methods approaches have often been used as an aid to sampling, with, for example, questionnaires being used to screen potential participants for inclusion in an interview programme.

6.3 The Research Design

As revealed earlier, this study combines quantitative and qualitative methods to answer the different research questions, as proposed by Creswell (2003) and Johnson et al. (2007). The purpose for combining quantitative and qualitative data collection and analysis procedures in this research it is to provide a better understanding of the research problem and the research questions than is possible using a single approach (Creswell and Clark 2007). As discussed in Chapter one, the present study is designed to explore how mathematics is taught and learned in Ghanaian Junior High schools, with particular reference to teachers' teaching practices and students' learning experiences. These domains of teacher practices and student learning experiences require a concurrent examination to expose the interrelationship between them. This requires both specific and holistic examination of these domains and both quantitative and qualitative data collection and analysis, as proposed by Shane (2000).

In general, the purpose for using a mixed methods design in this study is to use diverse data collection and analysis procedures to find answers to the different research questions raised. That is, different sources of data are used to answer the different, but complementary research questions. Table 6.1 presents the data sources used to answer each research question.

Table 6. 1: Research Design Matrix

Research Questions	**Type of data**	**Instrument(s)**
What teaching methods are used by mathematics teachers?	Quantitative & Qualitative	Questionnaire Observation & Interview
Why do mathematics teachers use these teaching methods?	Qualitative	Questionnaire & Interview
Is there any relationship between teachers' perception of their teaching practices and what they actually do?	Quantitative & Qualitative	Questionnaire & Observation
What are students' perceptions of their teachers' teaching practices?	Quantitative	Questionnaire
What are students' experiences of learning mathematics?	Quantitative & Qualitative	Questionnaire, Observation & Interview

The present study uses survey questionnaires that consist of both closed ended Likert scale questions (quantitative data) and open ended questions (qualitative data) to answer the five research questions. Semi-structured interviews and classroom observations in four selected schools also provide qualitative data to answer research questions 1, 2, 3 and 5. The quantitative portion of this study is aimed at gathering baseline demographic data regarding the participants, teachers' perceptions of the teaching practices, students' perceptions of their learning experiences and students' perceptions of their teacher's teaching. The data from the open ended questions in the questionnaires, the classroom observation and individual interviews provide statistics which are used to understand what the participants actually do in their mathematics classrooms, as well as the participants' views about mathematics teaching and learning. The framework used for the collection and analysis of the different sources of data is shown in Figure 6.1.

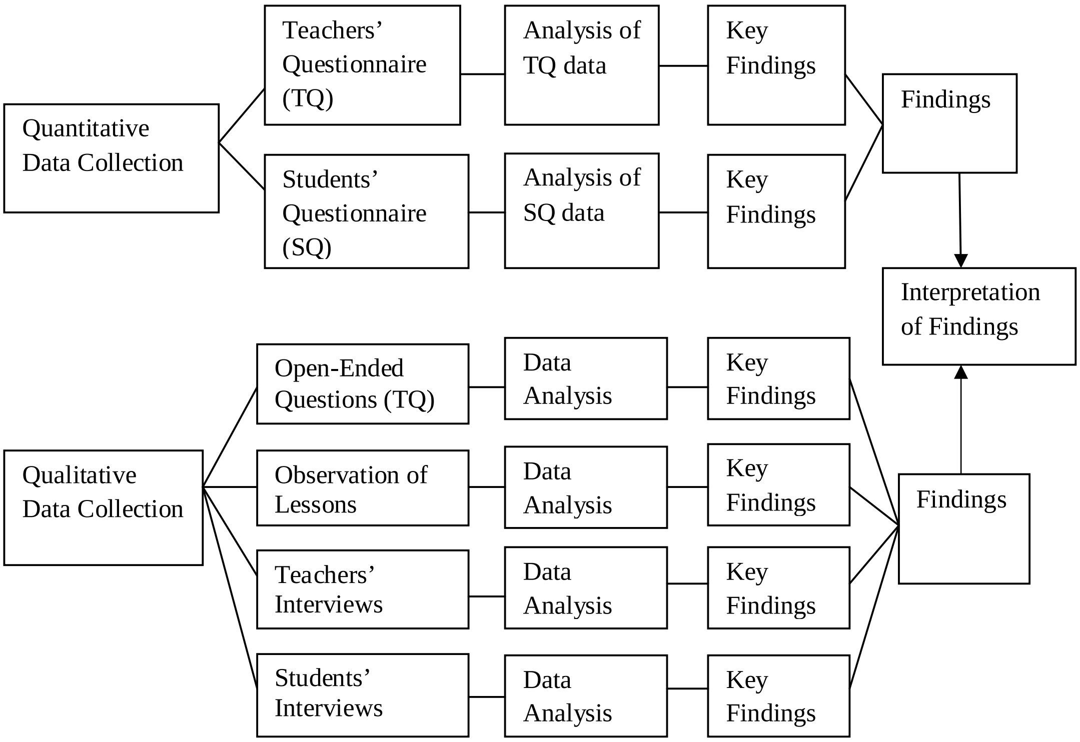


Figure 6. 1: Framework for Data Collection and Analysis

Despite the significant advantages of mixed methods research, the research design, like any other research design, has a number of limitations. According to Bryman (2004, 2007), quantitative and qualitative research strategies are two different paradigms with their own epistemological considerations and they are incompatible; hence, the integration is only at a superficial level and within a single paradigm. In addition, Craike (2004) also argues that one of the main limitations of mixed methods research is inconsistency in terminology. She explains that since the evolution of mixed method approach research, terms have been described differently and this inconsistency in terminology continues to be one of its pitfalls.

These limitations are, however, not significant enough to prevent the use of mixed methods research design in this present study, since it aims to provide a holistic picture of the problem under investigation. When finding answers to my first research question, I could have hypothesised a mismatch between teachers' perceived and actual teaching practices and employed a quantitative approach through the use of a questionnaire to gather large scale data to make inferences for the purpose of generalisation. On the other hand, I could have used a qualitative approach with a few selected schools and conducted some in depth analysis of the problem under consideration. However, the use of either approach or any single approach will not allow the construction of a much fuller picture of the problem and the case under consideration (De Vaus 2001).

6.3 The Research Strategy

Two research strategies were used in this study: exploratory survey and case study. Figure 6.2 presents a visual model of the strategies used.

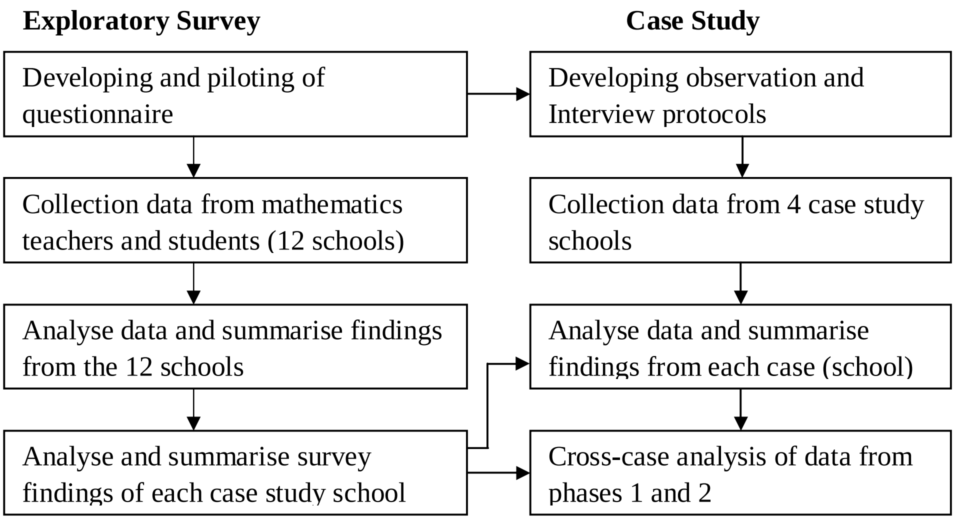


Figure 6. 2: Framework of the Research Process

The choice of these strategies was informed by the purpose of the research and the research questions. Firstly, a survey approach was used to collect data about teachers' and students' perceptions of their classroom practices. The survey approach was considered appropriate at this stage because I was interested in establishing how teachers and students perceive their classroom practices and the best way to collect such data was through the use of a survey. The use of this strategy therefore provided me with quantitative data which was used to map out the perceptions of mathematics teachers and their students regarding their teaching and learning processes.

The other purpose of the study was to assess what teachers and students think about their classroom practices and what they actually do during their mathematics lessons. In order to examine teachers' and students' actual classroom practices, a multiple-case study approach was used where I examined how the subject is taught and learnt through classroom observations and individual interviews during some selected lessons. Romberg (1992:57) describes a case study as the process of organising and reporting on information about the actions, perceptions and beliefs of an individual or group under specific conditions or circumstances. A case study therefore represents a systematic inquiry into a single case to shed light on a phenomenon by in-depth study to understand the complex relationship that exists among the participants in different contexts (Depoy and Gitlin 1998; Bryman 2004). Yin (2003) also defines a case study as a strategy of investigation into a real-life situation where the investigator has little or no manipulative control over the subjects investigated and which relies on multiple sources of data.

Different forms or types of case studies with different assumptions and purposes have been used in social science research and, for that matter, educational research. For example, Yin (2003:5) identifies five different types of case studies: the single-case study focusing on a single case only, multiple-case studies (two or more cases within the same study), exploratory case studies used to define the questions and hypothesis of a subsequent study, descriptive case studies which represent a complete description of a phenomenon within its context, and finally explanatory case studies, which present data on a cause-effect relationship and explain how events happened. Stake (1994) suggests that the purpose of the study and the motivation behind the study is central to the choice of case study strategy and type of case study undertaken. Stake therefore identifies three purposes for using case studies: intrinsic (motivated by personal desire and experience), instrumental (to generate theory or greater insight whereby the specific case becomes secondary), and collective (applying instrumental study to multiple cases within the same system to generate or refine existing theory).

As discussed in Chapter 1, the choice of this topic was necessitated by limited research evidence in the area of mathematics teaching and learning within the Ghanaian context and the case study approach is appropriate for investigating practices or programmes that have not been studied in-depth or have limited research evidence (Creswell, 2007b). Yin (2003) recommends that a case study approach is highly acceptable when the research is conducted in a real-life context and when the researcher has little control over events. In actual fact, the choice of a case study approach for this phase of the study is primarily informed by the aim of the study, which is to discover further insights into the problem under investigation and the lack of literature on the pertinent issue.

Moreover, since the introduction of the new mathematics curriculum in 2007, very little is known about how the subject is taught and learnt. The multiple-case study approach is considered appropriate in order to achieve further insight into this topic, as, unlike the single case study method, multiple case studies provide robust grounds for collecting and analysing different data sets from different sources (Yin, 2003). Walford (2001) and Yin (2003) agree that using a multiple case study not only provides a robust approach, but collecting data from these different settings can produce similar results and conclusions. Marshall and Rossman (1999) also argue that collecting data from different settings could increase the researcher's ability to generalise the results to a greater population through a thick description of the research process and findings.

Despite the numerous advantages of the case study approach, one of its major pitfalls is its subjective nature, which normally contributes to a degree of bias and this makes it difficult to establish reliability and validity in case study research (Patton, 2002). Another major limitation of the case study is the inability of researchers to generalise their findings to a larger population (Petrou, 2007). Case study research is obviously inconsistent with the requirements of a statistical sampling procedure, which is considered to be fundamental to generalisation of research findings (Schofield 1990:203). However, despite these criticisms, the case study strategy continues to be one of the most common approaches in social science research because of its numerous advantages. For example, this strategy allows for the study of every element present in the setting in which the inquiry takes place and this provides a holistic picture of the situation under consideration (Merriam 1998).

Furthermore, using a case study strategy helps to illuminate the general by looking at the particular; in other words, an insight gained through looking at individual cases can have wider implications that would not have come to light through the use of a strategy that covers a large number of instances; for example, the survey approach (Denscombe 2007). Also, case study strategy has a long tradition of collecting qualitative data to validate quantitative data and helps to reveal how a multiplicity of factors can interact to produce a unique character of entity which is the subject of the research (Thomas 2003:31). In general, the primary motivation for using a case study approach in this research was informed by its connection with the chosen research paradigm and the research focus, which aims to investigate mathematics teachers' teaching practices and students' learning experiences in their 'natural' setting.

The use of a case study research strategy has a long tradition in educational research in general and mathematics education research in particular, and a number of researchers have adopted this approach to investigate different research problems. Ngoepe (2003) uses a case study approach to investigate secondary school mathematics teachers' classroom practices, as does Chapman (2006) in examining classroom practices in the context of mathematics word problems. Mapolelo (2009) investigates students' experiences with mathematics teaching and learning by employing a case study design, whereby he collected both quantitative and qualitative sources of data to understand the phenomena under investigation. These studies are designed within a case study approach and the researchers use different data collection instruments to develop an understanding of the problems under investigation.

According to Yin (2003) and Stake (2000), the major strength of collecting data from different sources and settings is that it provides multiple measurements of the same phenomenon that can be compared and integrated for an in-depth understanding of the problem under investigation; this is documented in the literature. Silver (2004) states that "we would be wise to examine carefully research designs and methods we use and note that issues of deep concern to the field of mathematics education can be studied using quantitative as well as qualitative data collection and analysis procedures" (p. 155). Boaler (2008) suggests that it is critical for researchers to gather sufficient evidence from different settings and circumstances by using a range of quantitative and qualitative methods to better understand the issue under consideration. Also, Hart *et al.* (2009:27) opine that the current issues in mathematics education warrant multi-faceted research design and strategy. They further argue for the collection of both quantitative and qualitative data from different settings to thoroughly understand a research problem and provide a holistic picture of the issue under consideration.

In sum, based on the purpose of the study and the research questions, the multiple case study approach is considered appropriate in developing a holistic view of the phenomenon under consideration. In addition, as the present study does not aim to test any theory, but to understand the problem under investigation from different settings, the multiple case study approach is considered ideal as compared to a single case study approach.

6.4 Methods of Collecting Data

Three methods were used to collect the data for this study: survey questionnaires for teachers and students, observation of teaching practices and interviews with teachers and students.

Teachers' Questionnaire

The teachers' questionnaire is semi-structured with 34 questions and is divided into four sections: demographic information, the teacher's priorities, teaching methods and perceived classroom practices (Appendix C). Section A, comprising seven questions, elicits information about the school, its location and the teachers' background. The first question in this section collects information about the school and its location. The purpose of this question is to gather background information about the schools in order to categorise the schools into rural and urban.

The next four questions in section A seek to collect information about the teacher's gender, age and professional qualifications. In Ghana, teachers' professional qualifications fall into two categories: trained and untrained teachers. Trained teachers have completed a teacher's certificate 'A', a diploma in education and a degree in education from an institution of higher learning. Untrained teachers, on the other hand, are teachers who have not completed any of the above mentioned programmes, but are nevertheless teaching. Questions six and seven were used to collect information about teachers' training and whether or not they studied mathematics as their major, minor or as a core subject during their diploma, undergraduate or postgraduate education. The purpose of these questions is to ascertain the content knowledge of the teachers.

Section B of the questionnaire has two open ended questions. The first question was used to gather information about the teacher's priorities when teaching. This question has five sub-questions and the respondents were asked to rank five different priorities of teaching in order of importance, with one being the most important and five being the least important. The second question in this section elicits information about the teacher's perceived preferred teaching methods. To achieve this, all the teachers were asked to indicate how often they think they use the following teaching methods: lecture, activity, demonstration, group work and discovery. The teaching methods are limited to these five in the present study as these methods constitute the common teaching practices in Ghanaian schools (Adentunde 2007).

The purpose of section C is to elicit the teachers' perceptions of their own teaching and establish how teachers perceive their students' learning experiences; 25 closed ended questions were developed to gather this information. The questions in this section are further categorised into three sub-sections. The first sub-section features five questions aimed at eliciting information about the teachers' perceptions of their teaching. The next 14 questions collect information about the teachers' perceptions of how their students learn during mathematics lessons. The final six questions were content specific about evaluation and assessment, as prescribed in the mathematics curriculum of junior high schools in Ghana. These questions seek to gather information about the teacher's perception of how their students' learning is evaluated; all the questions were measured using a 4-point Likert-type response format (*1=strongly agree, 2=agree, 3=disagree and 4=strongly disagree*).

The Students' Questionnaire

The student questionnaire has 37 closed and open ended questions and is aimed at collecting information on the students' learning experiences and their perceptions of their teachers' teaching practices (Appendix D). The students' questionnaire is divided into three sections; section A has seven questions to elicit each student's personal data and the extent to which they like mathematics.

The first three questions gather personal information about the students and their school. The next three questions assess whether students like mathematics and if they intend to read mathematics related subjects at senior high school. Question seven gathers information about how often students learn mathematics at home. These questions are asked in order to establish some sort of background information regarding the students' experiences of learning mathematics. Section B has 12 questions assessing the students' learning experiences which are intended to examine the students' perceptions regarding how they learn mathematics in their respective classrooms. Section C features 27 questions which gather information on the student's perception of their teachers' teaching practices in order to compare this data with teachers' beliefs regarding their own teaching practices.

Similar to the teachers' questionnaire, sections B and C of the students questionnaire use a 4-point Likert-type response format (*1=strongly disagree, 2=disagree, 3=agree and 4=strongly agree*). One of the main disadvantages of using a four point scale is that it limits the respondents' choice to either agreeing or disagreeing to a statement and Nworgu (1991) argues that a 5-point scale gives room for undecided responses. However, not only does a 4-point Likert-type response format improve the statistical strength of the results, a weight of three to undecided responses is considered to be illogical and would make the data analysis inefficient (Swan 2006). Therefore, the 4-point Likert scale is considered to be appropriate for this instrument for the purpose of efficiency in the data collection and analysis process.

The development and process of designing the questionnaire took place in two phases and was informed by Swan's (2006) teachers' and students' workbook questionnaire. Firstly two semi-structured questionnaires (Appendices A and B) were developed, one for mathematics teachers and the other for students. All the questions in both questionnaires are drawn from Swan's questionnaire, although there are some minor modifications in terms of language structure.

The Process of Developing and Piloting the Questionnaires

The purpose of the pilot is to test the appropriateness of the original questionnaire for the present study within the Ghanaian context, as the original instrument was administered to students from different cultural backgrounds and from different year groups than the sample used in the present study. The teachers' pilot questionnaire comprises 10 questions, and the first question is a closed ended question asking about the location of the school. The other nine questions are open-ended questions about teachers' perception of their classroom practices.

The students' pilot questionnaire has 10 questions; the first seven questions are closed ended and address how much they like mathematics and their perception of their teachers' teaching practices. The last three questions are open-ended and elicit information about the kind of problems they face when learning mathematics and how they think their interest in mathematics could be improved. The two questionnaires were piloted in January 2009 in one school with 21 students and one mathematics teacher. However, since I was interested in obtaining different views from teachers, the mathematics teacher in this school was used as a point of contact to reach eight other mathematics teachers in four other schools and they were requested to complete the teachers' questionnaire. After administering the questionnaire, I observed one lesson to gather more information to support the data from the semi-structured questionnaires and, in doing so, examined how Swan's questionnaire could be used within the Ghanaian context.

Swan's questionnaire has a high Cronbach alpha reliability coefficient of 0.85, showing that the scales are reasonably consistent and reliable. After examining the responses from the questionnaire and the observation notes, it was noted that most of the questions were relevant in the Ghanaian context and met the purpose of the present research. However, the structure needed some modification in terms of clarity and language. For example, the results of the pilot study reveal that Ghanaian junior high school students' level of understanding of the questions was not the same as the original questionnaire which was administered to GCSE students who are at a higher level as compared to the participants in the present study. The feedback from the pilot study was then used to develop the teacher and student questionnaires used in the present study (see Appendix C and D).

The actual questionnaires were further piloted with some teachers and friends who were interviewed to establish whether they could understand the questions in the questionnaire. In addition, one student was also interviewed to test his understanding of the questions in the students' questionnaire and the feedback obtained was used to refine the questions into more simple language for clarity and understanding (especially in the case of the student questionnaire) before the final instrument was administered.

Classroom Observations

Observation is considered to be one of the ancient forms of data collection; it is an everyday life activity as we constantly observe the physical environment around us (Foster 1996). Three forms of observation are distinguishable in educational research: structured, semi-structured and unstructured observations. In a structured observation the observer knows in advance what he or she is looking for and normally has a checklist which has been prepared for that purpose. In a semi-structured observation, the observer normally has an agenda of the issues in a far less pre-determined or systematic manner, whereas in an unstructured observation the observer is normally not clear what he or she is looking to observe, but rather observes everything that occurs at the time before deciding on its significance to the study in question (Cohen et *al.* 2000).

LeCompte and Preissle (1993) also identify four main forms of observation based on the degree of the researcher's participation. The complete participant observation takes place when the researcher takes an insider role in the group he or she is observing and other members of the group may not even be aware they are being observed. The participant as an observer is normally part of the social life of the participants and records what is happening for research purposes by making his or intentions explicit to the group. The observer as participant is known as a researcher to the group he or she is observing and normally has less contact with the group. In complete observation, the participant does not realise that they are being observed and the role of the researcher is not made explicit (LeCompte and Preissle 1993). However, there is always a methodological dilemma regarding which type of observation should be used when investigating a particular research problem.

Researchers who use participant observation have been criticised for being unable to record important aspects or actions of the people being observed because of the researcher's active involvement in the process (LeCompte and Preissle 1993). Similarly, the non-participant observation suffers the limitation of not providing accurate information because the researcher just records what he/she is able to observe over the period of time (Cohen et *al.* 2000). However, Foster (1996) suggests that the choice of a type of observation should be informed by the purpose of the study and not be a mere selection from either participant or non-participant. The purpose of the classroom observation in the present study is to provide a complementary source of information to support and compare with the quantitative data from the questionnaire in order to help build a complete picture of what mathematics teachers and their students believe they do and what they actually do. Since I am interested in capturing the teaching and learning practices of mathematics teachers and students during mathematics lessons without manipulating the classroom situation, the only way to collect this useful data was through the use of the non-participant observation method. The observation data was collected through the use of observation protocol, which enabled me focus on the practices which were considered important for the present study.

Despite the importance of the observation protocol in structuring the observation process, the major challenge that I faced during the observation and interview process is what Rosenthal and Jacobson (1992) refer to as the 'Hawthorne Effect'. This is the situation whereby the person observed or interviewed may develop his/her own thoughts of what I may want to see or hear and will try as much possible to behave in a certain way or provide that piece of information to please me. The Hawthorne Effect was not significant during the observation, since I made familiarisation visits to the schools where I conducted the observations and the participants knew me before the actual data collection. However, the effect was significant during the interview process, as the first two students that I interviewed were suspicious that their responses would be disclosed to their teachers.

During the interview it was established that the students would either nod or shake their heads whenever they were asked questions relating to their teacher's teaching, although they responded to questions relating to their own learning experiences. This is likely to be because they were being tape recorded and were very careful with what they said about their teacher's teaching. In both cases I had to pause and reassure these students that whatever they said would not be disclosed to their teacher or anyone else. After the reassurance, the students started talking and responding to the questions relating to their teacher's teaching. The two students were therefore interviewed twice and the second set of interviews from these two students, together with the interview data from the other schools, has been used for the data analysis.

The Observation Guide

In order to achieve consistency and uniformity in all the classroom observations, a common observation protocol (see Appendix E) was used. The development of the observational protocol was informed by the purpose of the study and research questions. Furthermore, since the purpose of the observation is to complement the data from the questionnaire, the observational protocol was developed in cognisance of the questions in the questionnaires. That is, the observation protocol was designed in such a way that it captures most of the issues that the questionnaires were designed to target.

The observation protocol comprises four sections. The first section is used to elicit background information (school name and school type, teacher's gender, number of students, topic and class level) of the class being observed. The second section collects data about the lesson design and implementation. This section is used to gather information on how the lesson was designed and implemented, with significant emphasis on the teaching strategies used and the focus of the lesson. The different teaching methods (lecture, activity, demonstration, group work and discovery) which are distinguished in the literature are used as pre-determined themes in this section; however, consideration is given to emerging themes. The third section gathers information on students' participation, interaction and learning experiences in the lesson. Teacher-student interaction and student-student interactions are pre-determined themes used during the classroom observation; the last section seeks to gather information on how students' questions and misconceptions are resolved.

Interviews

Interviews are the most widely employed data collection method used to collect qualitative data. The interview is considered to be an information-gathering process conducted through verbal communication in order to understand the views of a person or a group of people on a particular phenomenon (Depoy and Gitlin 1998). Three forms of interviews are distinguishable in educational research: the structured interview, semi-structured interview and unstructured interview (Bryman 2004; Denscombe 2007). Structured interviews are generally recognised as questionnaires. Semi-structured means the interviewer normally has a list of questions he or she wants to cover, but which also allow for a certain amount of divergence from the script. In an unstructured interview the interviewer may have one or two themes that he or she wants to talk about, but generally follow the lead of the interviewee (Depoy and Gitlin 1998; Fontana and Frey 2003; Patton 2000).

Interviews are widely employed in educational research to collect data that are not readily observable, such as interests, values and experiences (Gall *et al.* 2007). In this regard, Byrne (2004) suggests that interviews are useful "for accessing individuals' attitudes and values-things that cannot necessarily be observed or accommodated in a formal questionnaire" (p.182). According to Denscombe (2007:203), direct contact during the interview means that data can be checked for accuracy and relevance during the collection process. Lawson and Philpott (2008) believe that interviews give participants the chance to provide natural responses which they would not be able to provide in a questionnaire. The main task of interviewing is to collect in-depth information about a given phenomenon where the lines of enquiry can be adjusted to suit both the interviewer and the interviewee (Drever 1995; Wisker 2001; Denscombe 2007).

Individual and group interviews are two different ways of interviewing participants and Lewis (1992) opines that group interviews provide richer responses and also allow for exchanges among participants. These exchanges give room for contradictory argument and discussions in order to better understand the relationship between the representation of the individual and that of the group in general. According to Fontana and Frey (2003), group interviews are normally preferred to individual interviews because group interviews provide clear similarities and differences in opinions and experiences between the different groups, which can be compared to provide a clearer picture of the problem under investigation. However, the disadvantages of group interviews have been well established by Breakwell (1990), Goodchild (2002b), Evens and Houssart (2007) and others. Apart from the issue of the possible domination of individuals in the discussion process, highlighted by Breakwell as one of the main disadvantages of group interviews, there are other practical challenges. For example, Goodchild (2002b), in exploring students' goals in classroom activity, utilised an unstructured group interview/conversation and reports that, although it provided enough data for his study, he lost his way in some of the conversation and lost some vital information because of the unsystematic and unstructured nature of the exchange.

Furthermore, Evens and Houssart (2007) utilised grouped (paired) interviews when examining how students approach mathematics questions with the hope that they would provide opportunities for interaction and discussion among the interviewees. However, in most cases, the results simply informed them of the answers from individual interviewees, as the interviewees took turns to give explanations that were not always influenced by their colleagues' comments. They further argue that although some of the groups provided some valuable interactions and discussions, most of the data collected could have been gathered using individual interviews (Evens and Houssart 2007).

For this present study, considering the research problem and questions for the present study and the challenges associated with group interviews, the individual semi-structured interview is considered to be the most effective form. The individual interview is preferred for three main reasons. Firstly, the study aims to examine teachers' teaching practices and students' experiences of learning mathematics, and individual interviews are considered appropriate to achieve this. The use of individual interviews helps to gain an in-depth understanding of the experiences of the individual interviewee, avoiding possible domination of the conversation by a few individuals (Breakwell 1990).

Secondly, confidentiality and anonymity are the two main ethical considerations with which this study strives to protect respondents' responses and identities; hence, using group interviews would have violated these ethical principles. Thirdly, individual interviews are considered desirable for this study because of insufficient resources to conduct group discussions, which require the recruitment of the participants, their preparation and the search for a venue which is appropriate for all the participants (Craike 2004).

The Interview Guide

For the purposes of uniformity, consistency and to structure the conversations, the interviews were conducted using interview protocols (see Appendices F and G). The teachers' interview guide has 15 questions; the first five questions are structured questions to elicit demographic data. The next seven questions are unstructured questions, seeking information on the mathematics teacher's priorities when teaching, which teaching methods are normally used and why they use these methods. The last three questions are aimed at gathering information on how mathematics teachers promote student participation during mathematics lessons.

The students' interview guide, on the other hand, has 14 structured and unstructured questions. The first four questions are structured and elicit demographic data, while the other 10 questions are unstructured and aim to collect data on the students' experiences of being taught mathematics. The interview protocols were piloted with one mathematics teacher and three students to ascertain their understanding of the questions.

6.5 Criteria and Selection of the Study Site and Participants

Population and Site of the Study

The target and accessible population for this study includes all junior high school students in the Cape Coast metropolis of Ghana (see Figure 6.3) and their respective mathematics teachers. According to Yin (1989*)*, researchers must select sites and participants that will contribute to the research and also provide further information to the research. There are other reasons for the selection of a particular site. Audet and D'Amboise (2001) and Yin (2009) opine that researchers select a site because of its convenience, accessibility and geographical proximity. Others select a site which they think may yield similar results or might provide different results to answer the research questions raised.

In the present study, the Cape Coast Metropolis was chosen because Central Region is a representative mix of rural and urban districts and the Metropolis exhibits some of these characteristics (Hedges 2002:355). In general, the selection of this site not only provides urban-rural data, but also produced both similar and divergent results, which lead to a deeper understanding of the problem under investigation (Audet and D'Amboise 2001). In addition, the selection of the Cape Coast Metropolis was informed by the results of the Performance Monitoring Test (PMT) conducted in 2001. This test puts the mean score in mathematics among junior high school students at 37.8 percent and between 2000 and 2003 only 20 percent of junior high school graduates qualified to enter senior high school (Cobbold 2006).

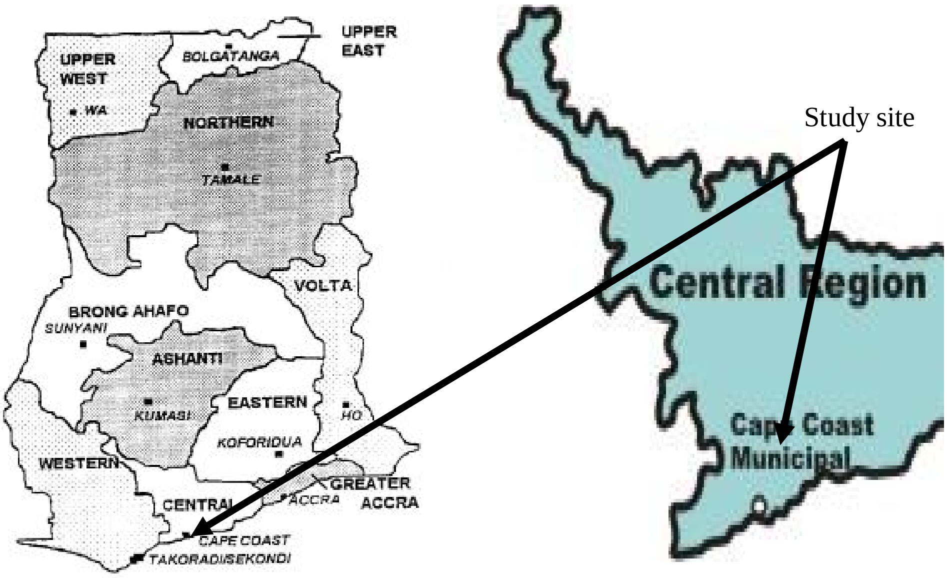


Figure 6. 3: Map of Ghana and Central Region of Ghana

The Central Region is the eighth largest in Ghana and covers an area of 9,826 km² with 17 districts and a total population of 1,593,823 (MoLG 2006). The study site, Cape Coast Metropolis, is one of the 17 districts in the central region; it has 71 settlements and a total population of 82,291, with 69.7% dwelling in the urban locality and 30.3% in the rural areas (MoLG 2006). The sample for this study was drawn from a population of 7,449 junior high school students and 495 teachers in the Metropolis (see Table 6.2). The Cape Coast metropolis is officially divided into six educational circuits, including 72 public junior high schools with 7,499 students and 495 teachers (GES 2008). The schools within the metropolis are located in communities with diverse demographic characteristics, mainly urban and rural communities. The Cape Coast Metropolis is divided into different educational circuits, however, as a way of maximising the variation in the sample; the location of the school and the school type (urban and rural) were taken into consideration during the sample selection.

Table 6. 2: Enrolment of Students and Teachers in Cape Coast Metropolis-2008/2009

Level	Number of Schools	Student Enrolment	Number of Teachers
Pre-School	56	4415	n/a
Primary	71	16,724	450
Junior High School	**72**	**7,449**	**495**

Source: Ghana Education Service (GES) 2008.

Criteria for Selecting Participants

The sampling procedure for this study took place in two phases. Firstly, the 72 public junior high schools in the six educational circuits were purposefully divided into 12 groups of six. That is, the schools in each circuit were divided into two groups (rural and urban schools) and each school was assigned an identification number. The Ghana Education Service (GES) categorisation of urban and rural schools scheme was used to classify these schools. A school was randomly selected from these 12 groups in order to increase the maximum variation of the study sample. The 12 schools, comprising six rural and six urban, were used to collect the survey data.

It was anticipated that a total of 360 students (that is, 30 from each school: 10 each from grades 7, 8 and 9) would be selected randomly with the help of the class teacher to complete the questionnaire. However, when I visited my first school there were 12 students who were present at that day and all 12 students consented to take part in the completion of the questionnaire. For uniformity, I selected 12 students from each class instead of the anticipated sample of 10 students and a total of 432 students completed the questionnaire (see Table 6.3). All the mathematics teachers in the 12 selected schools formed part of the study sample and it was anticipated that all the mathematics teachers in the 12 junior high schools (approximately 36 teachers) would complete the teachers' questionnaire. However, in most of the selected schools, there were either one or two mathematics teachers for the three classes instead of one for each class, as anticipated. Although there were 25 mathematics teachers in the selected schools, one of the teachers was leaving to pursue further studies at the time of the research, so he was not included in the actual sample. In all, 24 mathematics teachers from the sampled schools completed the questionnaire instead of the anticipated 36 mathematics teachers.

Table 6. 3: Population and Sample Size

Educational Circuits	Number of Schools	Sampled Schools	Anticipated Sample Size		Actual Sample Size	
			Students	Teachers	Students	Teachers
Circuit A	10	2	60	6	72	3
Circuit B	12	2	60	6	72	4
Circuit C	17	2	60	6	72	5
Circuit D	11	2	60	6	72	3
Circuit E	11	2	60	6	72	5
Circuit F	11	2	60	6	72	4
Total	**72**	**12**	**360**	**36**	**432**	**24**

Of the 24 mathematics teachers who completed the questionnaire, 23 consented for their lessons to be observed and to be interviewed, and all the 358 students who returned their questionnaires also consented to take part in the second phase of the study. The 12 schools were therefore divided into two groups (urban and rural schools) of six and two schools were purposefully selected from each group for the collection of qualitative data through the use of classroom observation and interviews. This sampling technique was intended to achieve a fair representation of students and teachers from both rural and urban schools within the metropolis. In doing so, the selection of cases from a much larger target population adds credibility by generating qualitative results to complement the quantitative -oriented research that also took place (Teddlie and Yin 2007). Moreover, as suggested by Patton (2001), the reason for using this purposive sampling design to select the four schools (cases) from different locations was to help to reduce suspicion over why certain cases or samples were selected; it also helped to collect data from different classroom environments.

6.6 Data Collection Procedures

The Process of Administering the Questionnaire

The two questionnaires were administered to all 24 mathematics teachers and the 432 selected students in the 12 sampled schools in the Cape Coast Metropolis of the Central region of Ghana between January and March 2010. Before administering the questionnaires, I went to the education directorate to seek permission to conduct the research in the selected schools (see Appendix M). I then visited the sampled schools to officially introduce myself to the teachers and students in order to officially seek their consent, although they had consented to take part in the study in a telephone conversation. During these visits, the purpose of the study, as well as the purpose of the questionnaire and instructions for its completion, was discussed with the teachers and the students.

Furthermore, the participants were given the participant information sheet and the consent form, which needed to be completed before the questionnaire. I went through the participant information sheets and the consent forms with the participants and they were given the chance to ask questions in case they needed further clarification. In all the schools visited, all the mathematics teachers and their respective students were willing to take part in the research after I read the participants information sheets with them and assured them of the confidentiality of their responses.

Challenges Encountered when Administering the Questionnaires

Although questionnaires have a high level of anonymity for respondents, represent an efficient use of time, offer the possibility of a high return rate and use standardised questions, like all other techniques for collecting data they have a number of limitations (Munn and Drever 1995). For example, in the present study, despite the willingness of the selected participants to participate in the research, the issue of the return rate of completed questionnaires was of great concern. Considering the number of teachers who agreed to complete the questionnaire, there was a need to devise a mechanism that would ensure a high response rate to promote confidence in the results. Although there is no single best way to achieve this, Liam and Fletcher (2002) suggest that giving financial incentives to respondents improves the return rate. Singer and Kulka (2002) also add that such incentives are useful tools to increase response rates.

The process of giving such incentives poses a threat, as paying respondents for their opinions might bias the data collection process and I considered this to be unethical. For example, Head (2009) states that giving financial incentives to her participants had a positive influence on participation and response rate; however she argues that paying these participants involved some practical, ethical and methodological issues, making her study unethical. Seeking to minimise this challenge, and learning from Head (2009), I personally administered the questionnaire to the respondents and this helped me to retrieve them as soon as they were completed.

Although I personally administered the teachers' questionnaire, I had problems with the collection of the questionnaires as almost all the teachers wanted to complete the questionnaire in their spare time. I therefore had to ask the teachers to give me a date and time that they thought would be convenient for me to collect the questionnaires and in a number of cases they had not had time to complete it. Most of the teachers suggested that I collect the questionnaires on the last day of the data collection, that is, when I had finished visiting all the 12 survey schools. However, since I needed these questionnaires back to establish the number of teachers who had consented to be observed and interviewed or to take part in the second phase of the study, I had to persuade the respondents to complete the questionnaires for me and sometimes had to wait until lunchtime for the teachers to finish.

However, despite the limitations of using questionnaires, in studies where a large number of the target population is dispersed in different locations, the questionnaire is considered to be desirable to collect data about teachers' and students' perceptions about their mathematics classroom practices. The issue of uncompleted questionnaires was another major challenge in this study. A number of the respondents (especially the teachers) failed to complete the questionnaire in full and several did not provide the names of their school location, which was meant to be used in the follow up observation and interviews for the collection of the qualitative data. Most teachers were concerned about the names of their schools being disclosed in the report, and I had to reassure them that these names would not be disclosed in the report and a copy of the completed report would be made available to them if they wished. I had to go back to these participants for them to complete those questions and it took me an extra two days to do this.

The Process of Conducting the Observations

The observation was carried out at the time when teachers were carrying out their normal scheduled teaching. The classroom observations were conducted between January and March 2010, after the individual questionnaires had been collected and those teachers who consented to be observed and interviewed had been identified. During the observation process I sat at the back of the classroom watching, recording and taking notes as the teacher taught and in some cases I sat on the veranda and observed. In so doing, I was able to observe and record the actual mathematics classroom practices without interfering in the teaching-learning process and the data was used to identify the relationship between teachers' and students' perceived and actual classroom practices.

It was anticipated that I would observe 12 lessons, that is, three in each school (one each for the three levels; JHS1-3) in the four selected schools with each lesson lasting for 35 minutes, which is the duration of a period in Ghanaian junior secondary schools. However, one of the four case study schools had only two classes (JHS 1 & 2) and in another school the two mathematics teachers agreed to be observed once only, so the actual number of observations was 10 instead of 12.

The Process of Recording the Observations

The classroom observation was recorded by means of taking detailed field notes with the help of an already prepared observation protocol. In addition to this, with the consent of the participants, I audio taped the classroom activities to complement the detailed field notes, since audio recording is considered to be less obtrusive than video recording. Although I sought the participants' consent before recording the classroom proceedings, before the observation I had a discussion with each of the teachers to establish whether there was any aspect of the lesson that they prefer not to be recorded and all the teachers agreed that every aspect of the lesson could be recorded.

The main challenge of this approach to recording classroom observation is that it does not produce audio and visual data which the researcher could use to re-examine data again and again from different points of view (Patrikainen 2005; Hamersley and Atkinson 2007). However, placing a video camera in the classroom can disturb or even change the course of events and thus affect the normality of classroom activities (Mosvold 2005). Moreover, combining video recording and the taking of notes can be cumbersome and important aspects of the classroom process may be missed if there is a technical problem with the camera which needs to be addressed (Patrikainen 2005).

The Process of Conducting the Interviews

The purpose of the interviews was to collect follow up data to complement the observation data; it thus made sense to conduct the interviews after the observations. The six mathematics teachers whose lessons were observed were interviewed after the observation to elicit their views on why they teach the way they teach and what they consider to be their main priority when teaching. Furthermore, 22 students were interviewed to extract their views about their experiences of being taught mathematics. In each of the 11 classes, two students were selected with the help of the teacher to be interviewed individually for the purpose of confidentiality; however, participation was voluntary.

The Process of Recording the Interviews

In the present study, two strategies were used when recording the individual interviews. Firstly, in all the interviews, I took notes of the participants' responses during the conversation. In addition, all the interviews were audio taped with the consent of the interviewees. The purpose of audio taping the interview was to obtain a full and accurate record of the interview to facilitate the process of making sense of respondents' responses (Craike 2004). Although audio recording of interviews is one of the easy ways to retrieve information, Merriam (1998) suggests that, for ethical reasons, when a respondent prefers not to be audio taped the researcher should look for another means of recording their conversation with their participants. The act of taking notes during the interview conversation is a second means of recording in case any of the interviewees decided not to allow his/her conversation to be tape recorded.

6.7 Data Analysis Procedures

According to Creswell and Clark (2007), one of the procedures used for mixed-methods research data analysis is concurrent data analysis, whereby both the quantitative and qualitative data are analysed separately. They explain that this data analysis procedure "involves the concurrent, but separate, collection and analysis of quantitative and qualitative data so that the researcher may best understand the research problem" from different perspectives (p.62). The procedure for analysing the data from this study is shown in Figure 6.4.

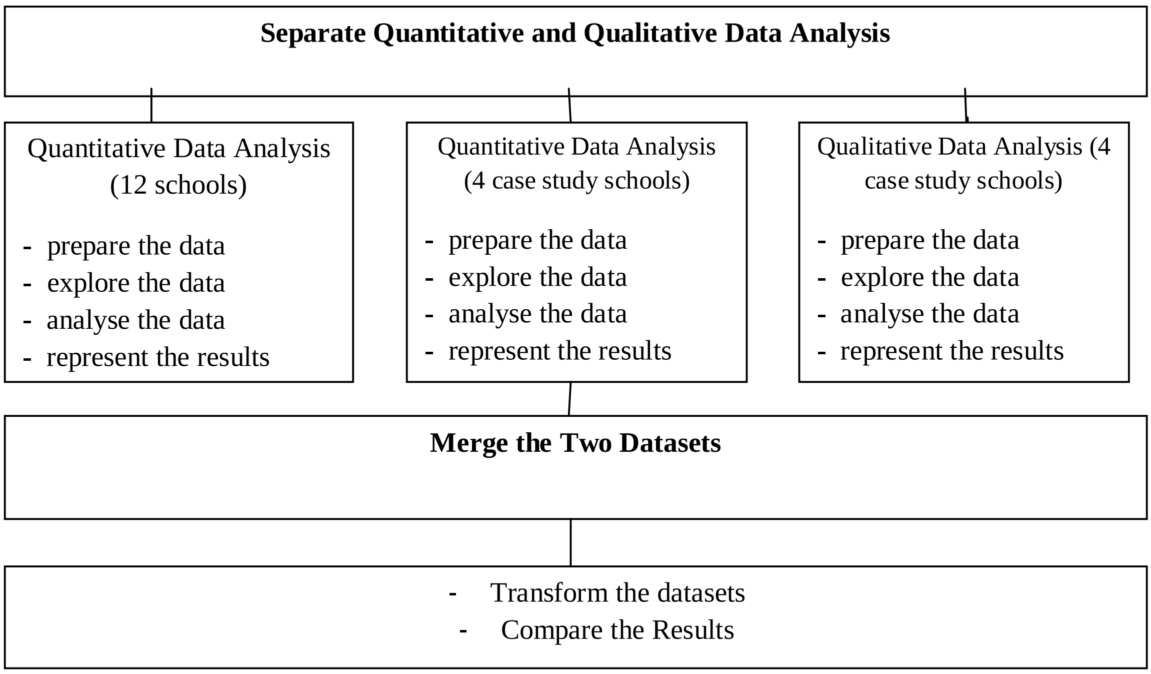


Figure 6. 4: Concurrent Data Analysis Procedure

Source: Creswell and Clark, 2007, p.137

In this study, the quantitative and qualitative data were analysed separately using Kelchtermans *et al.'s* (1994) approach of vertical and horizontal data analysis. The vertical analysis focused on the scrutiny of the individual sets of data obtained from the three data sources (the questionnaire, observation and individual interviews) for the purpose of identifying categories and themes within each individual data set. After the vertical analysis, a horizontal analysis was performed whereby the themes and categories obtained from the individual analysis were brought together, compared and integrated to provide a holistic picture of the situation under consideration (Kelchtermans *et al.* 1994).

According to Trochim and Donnelly (2007), the use of visual imagery and graphics in presenting data is “particularly valuable in making the logic of mixed-method design explicit” (p.183). When representing and displaying the quantitative and qualitative datasets, a multimodal approach was used whereby the datasets were displayed in different forms. In general, I used visual representations such as tables, charts and graphs when presenting and displaying the data to summarise the quantitative and qualitative datasets, as this makes the data meaningful and easy to understand (Creswell and Clark 2007).

Quantitative Data Analysis Procedure

The analyses of the data obtained were conducted in two stages. In Stage 1, the quantitative data from the 12 schools were first analysed to gain a general overview of the participants’ perception of their classroom practices. After the analysis of the data from the 12 schools, I carried out individual case (school) analysis of the quantitative data from the four case study schools, the results of which were compared with the quantitative data from the 12 schools and the qualitative data from the four case study schools.

The analysis of the quantitative data in the present study utilises two strategies in order to crystallise meaning from the data collected from the questionnaire. Firstly, all copies of the questionnaires were examined to check accuracy and completeness, after which the schedules were serially numbered, edited, coded and fed into the computer and the data obtained was analysed using the Statistical Package for Social Sciences (SPSS), Stats Direct and Origin software. Secondly, descriptive Unitvariate (involving a single variable) and Bivariate (involving two variables) analysis procedures were used to describe the characteristics of the data collected using absolute numbers and simple percentages to generate a general overview of the respondents' responses (Thomas 2003). As highlighted in section 6.4, with regard to measuring teachers' and students' perceptions of their teaching and learning practices, the teachers and students were asked to indicate the extent of their agreement or disagreement using a four-point Likert scale. For the analysis of the teachers' and students' degree of consensus regarding the teaching and learning practices, a minimum of 70% was chosen to describe the degree of agreement or disagreement. In this study a consensus agreement is used to describe the total number of participants who "strongly agree or agree" with a statement. Similarly, a consensus disagreement is used to describe the total number of participants who "strongly disagree or disagree" with a statement. Results were recorded as statistically significant if the P value was <0.05 using the Mann-Whitney U-test. The Mann-Whitney U-test is considered to be appropriate for the present study due to the small samples of teachers and students in the individual schools. In addition, the distributions of the variables were not normal and the variables recorded were measured using arbitrary scales (1=strongly disagree, 2=disagree, 3=agree and 4=strongly agree), so non parametric statistics were considered appropriate (Green and Salkined 2008).

The data from the students' and the teachers' questionnaires were analysed under two main teaching and learning strategies distinguishable in the literature: teacher-centred and student-centred. The results from the teachers' and students' questionnaires were compared in order to identify the relationship between mathematics teachers' perceptions of their own teaching practices and students' perceptions of their teacher's teaching practices. In stage two, a cross case analysis of the quantitative data from the individual case study schools was performed. The purpose was to provide information from the different (urban and rural) schools on how mathematics is taught and learnt and in so doing build a holistic picture of how the subject is actually taught and learnt. Through this, I was able to summarise the data from each individual case study school, which was then compared with the qualitative data collected from each of these schools. In presenting the cross case analysis of the data from the questionnaire, the colour green was used to represent all positive attitudes of 70 percent or higher, the colour yellow was used to represent positive attitudes of between 50 percent and 69 percent and the colour red was used for positive attitudes with less than 50 percent.

Qualitative Data Analysis Procedure

Two approaches to analysing qualitative data are distinguishable in the literature: structural and thematic analysis. The former focuses on the verbal and situational nature of the qualitative data gathered rather than its explicit meaning (Davies 2007). Thematic analysis, on the other hand, emphasises the generation of meaning from data gathered from the participant during a conversation or interaction (Davies 2007). In this study, analysis of the qualitative data was conducted using a thematic analysis approach, since I was concerned with what the participants said or did during the interview and classroom observation, rather than how they said or did it.

The analysis of such data requires an organisational and conceptual structure that allows different analytical tasks to help in making an informed judgement from the data collected (Davies 2007; Eady 2008). To achieve this in the present study, a data management and reduction strategy involving the transcription and categorisation of the themes obtained from the different data sets was adopted in order to sort the data into different categories for easy analysis. In this study, the data preparation and organisation process produced categories and themes which were aligned with the research questions for the study and provided the researcher with a rigorous and standardised way of achieving high validity in terms of the study results (Patton 2001).

The analysis of the qualitative data was carried out in two stages. In stage one I performed an individual case analysis of the findings from each case study school. In so doing, I was able to develop an individual data set describing how the subject is taught and learnt. The assertions about each individual case study school were then transformed and compared with the quantitative data from each individual school. To facilitate the comparison process, the qualitative data from the four schools were analysed with the same themes and categories used in analysing the quantitative data. That is, the data was analysed in cognisance with the teaching and learning strategies associated with behaviourism and constructivism. In stage two, I conducted a cross-case analysis of the findings from the four schools in which the summaries of the findings from the schools were compared to identify common themes and differences that were then used to generate a set of tentative claims (Stake, 2005). Similar to the cross-case analysis of the questionnaire, the key indicators in the classroom observation data were rated using a three point scale (1=occurred in most parts of the lesson; 2= occurred sometimes and 3= never occurred). The colour green was used to represent activities that occurred in most parts of the lesson, yellow for activities that occurred sometimes and red was used to represent activities that never occurred.

Analysing the Observation Data

The analysis of the classroom observation data drawn from the field notes and the transcription of the audio recordings of the 10 lessons was completed in cognisance of the research questions and, by doing so, the unit of analysis used was classroom practices which involved the teaching and learning strategies used. The first stage of the analysis of the classroom observation data was to develop an individual coding system for each lesson and the pre-determined codes and themes used were the content of the lesson and interactions and resources. Individual reports for each observed lesson were produced in order to identify common themes for categorisation. In the second stage, a cross-case analysis of the individual datasets from the four case study schools was performed and the summaries of the individual observation reports were analysed using the inductive analysis procedure, which focuses on searching for patterns and meaning in the data collected to build a general picture of the situation in the observed mathematics classrooms (Hatch 2002; Kislenko 2005).

Analysing the Interview Data

The analysis of the interview data was carried out in two stages; it was drawn from the field notes and the audio recordings of the five mathematics teachers and the 22 students who were interviewed. I transcribed each interview in stage one, after which the transcripts were analysed using the interpretational analysis method. This technique involved the reading and rereading of the transcripts to determine any themes or patterns which could be categorised to form initial emerging themes (Patton 2002).

In other words, after transcribing each recorded interview, I read through each transcription again and again to determine the common items from the data. The individual interview reports from the teachers were analysed and compared with the classroom observation data. Then the interview data from the individual students were grouped and the results were quantified and presented in graphical form. This was to present a holistic picture of the students' responses to the interview questions, rather than an individual picture of the students' views. In stage two, the summaries of the individual interview data were used to produce a cross-case analysis whereby the differing and similar themes from the individual cases were compared to produce further categories and patterns. This was then interpreted in order to draw conclusions.

Priority, Implementation and Integration of Data

As discussed above, the three data sets were collected concurrently. Since I was greatly interested in mapping out the situation on the ground at the initial stages of the research, the quantitative data from the questionnaire was given a significantly higher priority than the other data sets. However, people do not always act as they believe they act or do what they perceive themselves to do;

people's opinions of their actions are mostly inconsistent with what they actually do (Deutscher, 1973). Since I was also interested in establishing and understanding the actual classroom practices of teachers and students, during the data analysis stage the qualitative analysis component, especially the classroom observations, was the highest priority. As discussed above, in integrating the quantitative and qualitative data, the qualitative data sets were transformed into numerical ratings for easy integration and comparison (Creswell and Clark, 2007).

6.7 Ethical Consideration

Ensuring the validity and reliability of a research process involves conducting the investigation in an ethical manner throughout (Merriam 1998). In any research, including the present study, some ethical considerations need to be adhered to and they include the need for the researcher to: protect their participants and develop a bond of trust with the participants and promote the integrity of the research (Creswell 2003; Bryman 2004; Creswell 2009). Denscombe (2007:143-145) identifies three ethical principles that social science researchers ought to consider during the data collection, analysis and dissemination of the research findings stages of their study. Firstly, the interests of the participants should be protected and participants should not suffer as a consequence of their involvement with a piece of research. That is, there is a need to ensure participants do not experience any physical, psychological or personal harm as a result of their involvement in the research.

Secondly, the researcher should avoid deception or misrepresentation by operating in an honest and open manner with respect to their investigation. Thirdly, participants should give informed consent to indicate their willingness to take part in the study. That is, participation in research should be voluntary and participants should be given enough information about the study to arrive at a reasoned judgement as to whether or not to take part in the research. Similar to the ideas of

Bryman (2004) and Denscombe (2007), the major ethical considerations in the present study include: avoiding harm to participants, ensuring informed consent, respecting privacy and anonymity, avoiding deception and my role as a researcher.

To address these ethical issues, I first visited the selected schools to familiarise myself with the premises and people, introduce myself and seek permission to conduct the research. In addition, the purpose of the research was informally communicated to the selected schools and they were given the assurance that they would have the chance to decide whether they wanted to be part of the study or not. Consent to undertake the research was negotiated with key personnel in the metropolitan education office and the various schools selected (see appendices F and G). Firstly, I visited the metropolitan education office to collect my letter of permission, after which the consent of the head teachers in the various schools was sought. I then met the various mathematics teachers in these schools to discuss the purpose of the study. The mathematics teachers in these schools then introduced me to their respective classes and I had an informal discussion with the students at which I informed them of the purpose of the study and sought their consent informally.

All the participants were made aware that their involvement in this research project was voluntary and they also had the right to withdraw subsequently, without given any reason, and their participation or lack of it would not affect their academic work and whatever they say would not be disclosed to any other person. During my next visit to the selected schools, all the participants were given a copy of the participant's information sheet, together with two participant's consent forms (see Appendices H and I) which they had to complete and sign before the actual research. With the help of the teachers in the various schools, the participant information sheet was read out to the students, after which they could ask questions before they completed the participant consent forms.

Furthermore, I addressed all these ethical issues in the research ethics approval application which was submitted to Anglia Ruskin University, United Kingdom (see Appendix J). In the ethics approval application, the aims and rationale for the research was explained and details were given on how the participants would be informed. Furthermore, since most of the participants for the research were aged below 18 years, I applied for a Criminal Records Bureau clearance certificate which was one of the requirements which must be met to gain ethics approval at the university. As a way ensuring the avoidance of any harm and risk to participants, I explained in the ethics application that the participants would be made aware that their participation was voluntary and they were free to withdraw at anytime without giving reasons.

6.8 The Role of the Researcher

The researcher forms an inseparable part of the investigation and is considered to be the principal tool in the research process (Merriam 1998; Patton 2001). Ethical issues in research are not only present at the data collection stage, but the role of the researcher in the whole process is a very important ethical issue that must be considered (Cohen and Manion 1994; Creswell 2009). For example, Locke *et al.* (2000) opine that, in most research studies, the presence of the researcher in the lives of the participants presents ethical issues that need to be examined.

To minimise the researcher's effect on the research process, and to diminish the level of bias in the dissemination of information, most researchers try to be as neutral as possible during the data collection and dissemination process (Cohen and Manion 1994). However, Cohen and Manion (1994), Creswell (2003) and Creswell (2009) believe that the researcher's own beliefs, experiences and expectations normally influence and affect the data collection and dissemination of the study findings and it is difficult to eliminate this researcher effect. Similarly, David and Lopes (2002) also suggest that the influence of the researcher's feelings, experiences and perceptions cannot be eliminated completely.

My experiences and beliefs as a mathematics educator and researcher, including having taken up the opportunity to teach and be taught in different countries, may influence my perceptions during the classroom observations. This may increase the bias in my interpretation and reporting of the research findings; however, in the present study, a number of steps have been taken to minimise these effects. The reflexivity method has been used to reduce the effects of my experiences and perceptions. According to Creswell (2009, p.233), reflexivity requires the researcher to be objective about his or her experiences and how these personal experiences influence the interpretation formed during the study. To achieve this, I remained as objective as possible during the data collection and interpretation stages by recording and reporting exactly what happened. In undertaking the research, I acknowledge that my personal experience as a mathematics educator and researcher inspired my decision to research the topic.

The decisions that I made with regard to the questions to be asked, the study population, the methods, the methodologies chosen and how the data were collected and analysed have been influenced by my personal experiences and knowledge. In pursuit of methodological rigour, I acknowledge that researchers are part and parcel of the social world of which they research and the effects can never be completely eliminated. I reflected on these effects throughout the entire research process and acknowledge that the best policy is to recognise and understand how they have affected the overall study (Creswell and Plano 2007). Furthermore, I have ensured that all the conclusions are based on the data obtained from the participants; this was achieved by being neutral, especially during the data collection and analysis stages, to avoid influencing the research findings with my own interpretation (Stake 1995; Stake 2000).

6.9 Reliability of the Survey Instrument

Reliability refers to a fit between the data recorded by a researcher and what actually occurs in the natural setting (Bogdan and Biklen 1992). As emphasised by Babbie (2002), reliability is "a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time" (p.136). Cohen *et al.* (2007) describe reliability as the consistency and stability of a research instrument in terms of producing similar results when the same data collection techniques and instruments are used in another study. Creswell (2009) defines reliability as whether the scores indicate a research instrument which is internally consistent and whether there is consistency in the administration and scoring of the instrument. In general, reliability can be identified as the measure of consistency or stability of the research or assessment instrument used in collecting data.

In this present study, the assessment instruments used were the teachers' and students' questionnaires and reliability was achieved through the following measures. Firstly, I used an expository approach when designing and developing the questionnaires in order to improve the reliability of the questionnaires. In so doing, I observed one lesson and, using open ended questions, asked the teachers and students to provide a portrait of what they think they do in their respective classrooms. The portraits provided valuable data which reflected the respondents' views and, by doing so, provided a rigorous way to design and develop the questionnaires (Goodchild 2002b). Secondly, the questionnaires were piloted to ascertain the consistency of peoples' understanding of the questions and the feedback obtained from the pilot study was used when designing the final questionnaire.

6.10 Establishing Trustworthiness

Lincoln and Guba (1985) define trustworthiness as how the inquirer or the researcher can "persuade his or her audiences (including self) that the findings of an inquiry are worth paying attention to"

(p. 290). Trustworthiness is established through ensuring the validity of the research process. Validity refers to the accuracy and the authenticity of inferences drawn from research data, analysis, findings and results (Eisenhart and Howe 1992). Cohen et al. (2007) also define validity as the accuracy of research findings and how these findings reflect the actual behaviours or situations on which the findings of the study are based. To ensure that the findings of the present study are worthy of attention, the following measures were used to evaluate the trustworthiness of the study results:

Internal Validity/Credibility

The internal validity of research comprises how the explanations of a particular event, issue or set of data which a piece of research provides correspond with the actual views of the participants (Cohen *et al.* 2007). Schumacher and McMillan (1993) define internal validity as the extent to which the findings of a study accurately match the reality of the participants' views. In general, internal validity can be defined as the extent to which a study's design, data and process allows the researcher to confidently interpret the study's results to represent the actual views of the participants.

Internal validity was fulfilled in the present study through data (collection of data using different instruments) and methodological (use of different research approaches) triangulation. I used different sources of data (questionnaire, observation and interviews) and in so doing helped to minimise the limitations posed by the use of one particular method. Moreover, the methodological triangulation used in this study also adds rigour and richness to the research by compensating for the drawbacks of any particular research approach (Denzin and Lincoln 2003). Furthermore, internal validity was confirmed through appropriate record keeping. Similar to the ideas of Huberman and Miles (1994), the data from the questionnaires, observations and the interviews was kept for the purpose of re-evaluating the steps used and checking for consistency between the descriptions and the interpretations of the classroom context and what actually occurred in these classrooms. Huberman and Miles (1994) suggest that ensuring internal validity revolves around the retention and preservation of all forms of record, both notes and audio recordings, and this approach is widely used in the literature of mathematics education. For example, Goodchild (2002b:53) in validating his research findings, archived 10 percent of his data which was analysed after the interpretation of the main data set had been formulated in order to test the conjectures drawn.

External Validity/Transferability

External validity measures the degree to which the results and findings of a particular study can be applied to other similar circumstances and the wider population, cases or situations (Cohen *et al.* 2007:136). According to Ercikan and Roth (2009), external validity is "the degree to which research claims can be extended to contests and populations beyond those in the study itself" (p.10). Dellinger and Leech (2007) also define external validity as the extent to which study results could be generalised to different places or persons. In general, external validity is the successful generalisation of results, findings and conclusions to other contexts.

The issue of external validity is a key component of educational research and several measures have been taken by researchers to ensure that the findings of their studies can be applied to a certain population (Ercikan and Roth 2009). Creswell (2009), Habashi and Worley (2009) stated that the combination of both quantitative and qualitative methods improves the external validity of the research. In the present study, external validity was achieved through the use of multiple sources of data and the in-depth description of the research sample, the context of the study and the data collection and analysis procedures in the previous chapters. This process should extend the usefulness of the results and findings from the present study to other studies with a similar sample and sampling techniques; the research design thereby improves the external validity of the present study (Marshall and Rossman 1999).

6.11 Summary

This chapter has introduced the research design and strategies for the present study and the justification for the chosen design. More specifically, this chapter has outlined the process of developing the research instruments, which included questionnaires, observations and interviews. It has further detailed the population, participants and the selection procedures used to select the participants targeted for the collection of data at the various stages of the study. The data analysis procedure used at the various stages of the study to find answers to the research questions has also been discussed.

Ensuring validity and reliability of research involves conducting the investigation in an ethical manner (Merriam 1998). This chapter has therefore outlined the anticipated ethical considerations, as well the measures taken to minimise and address these ethical issues. Moreover, the strategies used to evaluate the reliability of the assessment instrument (questionnaire) have been explored. Finally, the chapter outlined the role of the researcher in conducting the research and how my beliefs have influenced the research process and what measures have been taken to minimise the effects of my role on the quality of the research results.

PART IV: RESULTS

Chapter 7

Results, Findings and Analysis of Questionnaire Data

7.1 Introduction

The purpose of this chapter is to present the results of the data analysis with regard to the teachers' and students' questionnaires. As discussed in Chapter 6, descriptive statistics were used to delineate the basic features of the quantitative data from the questionnaires. The reason for using descriptive statistics was to map out the perceptions of mathematics teachers and their students regarding their classroom practices. Absolute numbers, frequencies and percentages are used to present the results and findings from the teachers' questionnaires due to the small sample of teachers involved, as the use of percentages alone could be misleading. On the other hand, the results from the students' questionnaires are presented using absolute numbers and percentages.

The chapter is divided into seven sections. The first section discusses the response rates of the questionnaires and the implications for the present study. The second section explores the background characteristics of the participants, in order to give a general overview of the participants' baseline information. Section three examines teachers' teaching priorities and section four presents and discusses teachers' perceived teaching methods. Section five examines teachers' perceptions of their teaching and section six investigates students' perceptions of their learning experiences. The last section explores students' perceptions of their teachers' teaching.

7.2 Return Rate, Response Rate and Reliability

This section presents the response rate and reliability of the teachers' and students' questionnaires.

Teachers' Questionnaire

Of the 25 administered questionnaires, 24 were returned; however, two of the questionnaires were not fully completed. Since each individual questionnaire had consent form attached to it, I was able to identify the two teachers who did not fully complete their questionnaires. The reasons they gave for not answering those questions were that they wanted to be reassured regarding the confidentiality of their responses, despite the fact that this assurance was discussed in the participants' information letter. I approached the teachers to confirm that their answers and responses were confidential and that their names would not be disclosed to anyone or be mentioned in the final report. The two teachers then completed the missing information.

The reliability of the teachers' questionnaire was calculated using the Cronbach Alpha reliability coefficient. The reliability coefficient was found to be 0.75 and the instrument was considered to be reliable, as it exceeded the Cronbach Alpha reliability threshold of 0.7 (Huck 2000).

Students' Questionnaire

The students' questionnaire was administered to 432 students in 12 selected schools and, of this number, 358 completed questionnaires were returned, representing 82.9 percent. According to Gay and Airasian (2003), empirical research requires replicability and if the same results cannot be replicated then the conclusions for the study will not be valid. Gay and Airasian further add that a high degree of reliability and a reasonable response rate are essential to ensure the replicability of a study's results. They opine that a response rate of 60 percent or less in a survey normally raises doubts over the replicability of the study's results. With a response rate of 82.9 percent and a

Cronbach Alpha reliability coefficient of 0.74, the study results and findings could be replicated to other settings if the same research process was used.

7.3 Participants' Background Characteristics

Teachers' Background Characteristics

In Ghana, it is a national trend that there are more female teachers than male, especially in basic schools (Ampiah *et al.* 2000). In the Cape Coast Metropolis there was not that great a difference between the number of female and male teachers, as 50.7 percent of the total number of teachers in the 2008/2009 school year were males and 49.3 percent females (GES 2008). Interestingly, of the 24 mathematics teachers who completed the teachers' questionnaire, only three were females. Although there were as many male teachers as female teachers in the Metropolis, male mathematics teachers outnumbered their female colleagues.

Furthermore, 87.8 percent of the total number of teachers in the Metropolis were trained teachers and 12.2 percent were untrained (GES 2008). Of the 24 mathematics teachers who participated in this study, 20 were trained and studied mathematics at the teacher training colleges and universities, a result that is consistent with the Metropolis statistics. However, of this number, 11 studied mathematics as a core subject, five as a minor subject and eight as a major subject. These results show that the majority of the mathematics teachers had only received general training and were not trained mathematics teachers.

Students' Background Characteristics

Of the 358 students who returned the completed questionnaires, 41.3 percent were males and 58.7 percent were females. A total of 49.7 percent attended rural schools and 50.3 percent attended schools in urban communities. Moreover, 33 percent were in JHS 1, 33.8 percent were in JHS2 and 33.2 percent were in JHS 3. The students were aged between 11-19 years with a mean age of 14.4

years. The mean age of the male students was 14.6 years and that of the female students was 14.3 years.

7.4 Teachers' Teaching Priorities

Teachers estimated the relative weight they gave to five priorities by ranking them in order of importance, with 1 being the most important and 5 being the least. The priories in the questionnaire were: to prepare students to pass their exams; help students to understand mathematics; help students to appreciate the importance of mathematics; motivate students to have an interest in mathematics and to finish the syllabus. Figure 7.1 shows the frequencies of the number of teachers who ranked each priority as their first choice.

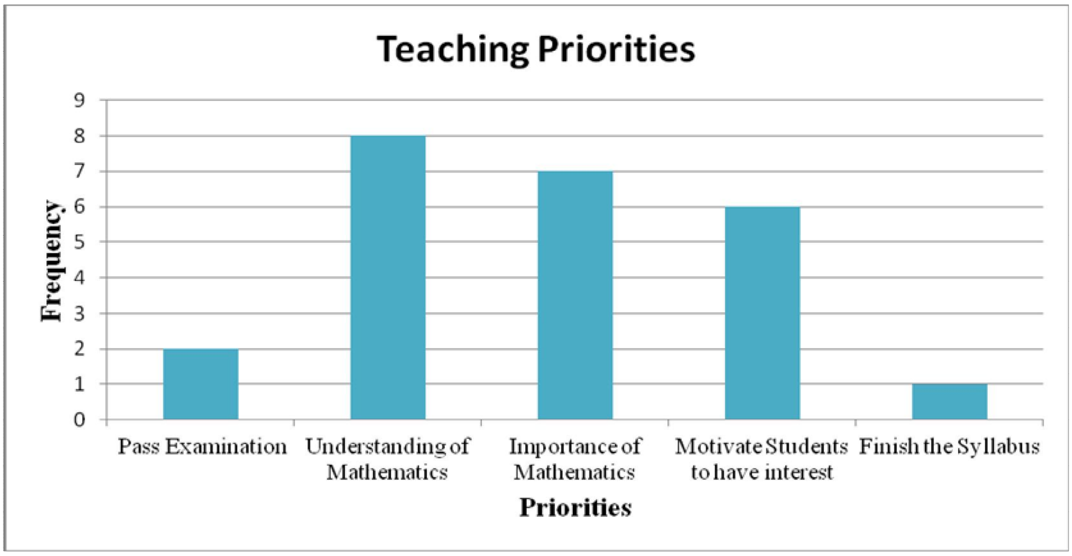


Figure 7. 1: Teachers' Teaching Priorities (N=24)

As shown in Figure 7.1, the three highest ranked priorities were helping students to understand mathematics, helping students to appreciate the importance of mathematics and motivating students to have an interest in mathematics. These are recognised to be of the most benefits in developing a conceptual understanding of mathematical concepts; students require this understanding in order to be able to make informed judgements and to apply the knowledge they acquire to solving problems

(Boaler 2009). It is also evident from Figure 7.1 that only two of the respondents indicated preparing students to pass their exam as their main priority and only one teacher indicated finishing the syllabus as his main priority. In general, the findings suggest that the majority of the teachers acknowledge the importance of helping and motivating students to develop a conceptual understanding of the mathematics they learn. The implication is that most of these teachers would employ a more student-centred approach in their teaching to help students develop an interest and be motivated to learn mathematics.

7.5 Teachers' Perceived Teaching Methods

In section B of the teachers' questionnaire, the teachers were asked to indicate how often they use five teaching methods identified in the literature which are often used in Ghanaian schools: lectures, demonstrations, discovery, activities and group work. The participants ranked the items above using a three point scale: never, sometimes and often (see Figure 7.2).

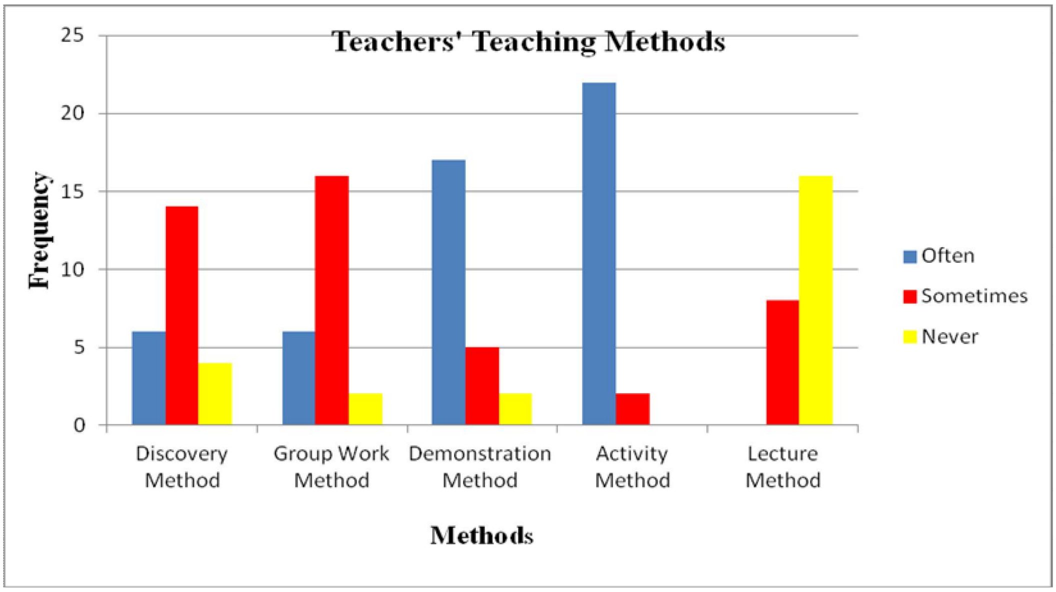


Figure 7. 2: Teachers' Perceived Teaching Methods (N=24)

Of the five teaching methods, the activity and demonstration methods were the most preferred and the lecture method was the least preferred option. Discovery and group work methods are in the middle range. Figure 7.2 shows that, as expected, teachers' perceived teaching priorities and perceived teaching methods are related and consistent with the national curriculum requirements. The most preferred methods agree with those identified and described by Ball and Bass (2000) and Boaler (2009) as necessary to promote students' active participation in the teaching and learning of mathematics. In summary, the results from Figure 7.2 show that the majority of teachers acknowledge the importance of student-centred teaching methods and the use of different teaching methods, as there was no single method of teaching selected. The application of one particular method of teaching mathematics is problematic, as argued by Mathews (1997).

7.6 Teachers' Perceptions of their Teaching

This study seeks to identify teachers' perceptions of their teaching practices. To achieve this, the teachers were asked to rank their perceptions of 14 items relating to their teaching. The results are displayed in Table 7.1.

Table 7. 1 : Teachers' Reported Practices (N=24)

Statements	Percent	Type
I start each topic by reviewing students' existing knowledge	100	Agree
I explain things carefully to prevent students from making mistakes	100	Agree
I go through a variety of methods when solving questions	100	Agree
I give students the procedures to follow	100	Agree
I use different teaching approaches when teaching	96	Agree
I use other textbooks and reference materials	96	Agree
I encourage students to use the method I teach to them	96	Agree
I ask students to complete easy tasks before attempting difficult ones	92	Agree
I use the national curriculum recommended teaching method	92	Agree
I ask students to work in small groups	92	Agree
I draw links between topics and move back and forth between topics	87	Agree
I teach all the topics in the syllabus	79	Agree
I tell students which questions to do	75	Agree
I teach each topic assuming my students know nothing	67	*

The results from Table 7.1 show that teaching starts with assessing students' existing knowledge and not with reading what the textbook says. In addition, as much as teachers try to use the national curriculum recommended textbooks and teaching methods, the majority of the respondents do not rely solely on these textbooks and teaching methods, but look for different reference materials, textbooks and different teaching methods. This is consistent with the national curriculum guidelines which entreat teachers to be proactive and innovative in their teaching and use different teaching methods and introduce students to different ways of solving mathematical problems.

Furthermore, the results show that teachers consider each individual learner's prior knowledge to be an important factor in the teaching-learning process, as all the participants indicate that they review existing knowledge before they start any lesson. These teaching skills are consistent with the findings described by Dochy *et al.* (1996), who establish that an individual learner's existing knowledge is important for effective teaching. The central tenet of constructivism, upon which the guidelines for the national curriculum are based, suggests that human learning is constructed, and learners build and develop new knowledge upon the foundation of previous learning. This therefore emphasises the importance of the individual learner's existing knowledge in the teaching-learning process.

However, despite the importance of prior knowledge in facilitating learning, the majority of the respondents also indicate that they teach each topic assuming their students know nothing and this suggests that teachers may review individual students' existing knowledge, but the design and implementation of the lesson is not determined by this prior knowledge. Furthermore, students' mistakes and misconceptions are recognised as necessary, as teachers can use these mistakes to evaluate their teaching and students' learning, as argued by Willis (2010). However, the results show that the majority of teachers try to avoid students' mistakes.

Feldler (1993) believes that individual students learn differently because they have different experiences and learning styles. They are able to comprehend and make meaning from teaching if the teaching method conforms to his/her learning style. It can be argued that, in a country where the national curriculum serves as a level platform for all students, prior knowledge or experiences that individual students bring to their respective classrooms could be assumed to be the same. Moreover, the majority of the respondents indicate that they use different teaching approaches and different methods to solve questions. Presenting a particular concept using different teaching approaches and methods to solve problems has been described as an effective technique to encourage students' conceptual understanding of mathematical concepts and a way of providing the rigorous structure of mathematical knowledge needed to make an informed judgement (Anamuah-Mensah and Mereku 2005; 2005a).

Furthermore, the majority of participants indicate that they use the prescribed textbooks and national curriculum prescribed teaching methods, which seek to boost students' active participation in the teaching and learning process. The use of these recommended textbooks sets a level playing ground for all learners and also serves as a source of reference material for both the teacher and student (Vincent and Stacey 2008). However, despite the importance of the textbook, over reliance on these tools and their examples and exercises is a recognised effect; a low proportion of real-life context application promotes '*shallow teaching and learning*', as argued by Vincent and Stacey (2008). It was however, interesting to note that, despite the great majority of the respondents indicating that they use the recommended textbooks and the national curriculum teaching methods, the results also establish that they do not rely solely on the recommended textbooks and teaching methods, but also use other textbooks and reference materials. Table 7.2 and Figure 7.3 present a descriptive statistics of teachers' perception of their teaching.

Table 7. 2: Descriptive Statistics of Teachers' Perceptions of their Teaching

Climate	Statements	Percent	Type
Student-Led Climate (Constructivism)	I start each topic by reviewing students' related knowledge	100	Agree
	I go through a variety of methods when solving questions	100	Agree
	I use different teaching approaches when teaching	96	Agree
	I use other textbooks and reference materials	96	Agree
	Students compare different methods of solving a question	96	Agree
	I ask students to work in small groups	92	Agree
	I draw links between topics and move back and forth between topics	88	Agree
	Students develop their own methods to solve problems	79	Agree
Teacher-Led Climate (Behaviourism)	I explain things carefully to prevent students from making mistakes	100	Agree
	I give students procedures to follow	100	Agree
	I encourage students to use the method I teach them	96	Agree
	I encourage students to work on their own	96	Agree
	I ask students to complete easy tasks before attempting difficult ones	92	Agree
	I tell students which questions to attempt	75	Agree
	I teach each topic from the beginning, assuming my students know nothing	67	*
	I go through one particular method for each mathematics question	54	*

The 24 teachers in the sample were asked to indicate the extent to which they agreed or disagreed with the constructivist view of teaching and learning and the behaviourist view using a four point based Likert scale (1- strongly disagree, 2- disagree, 3-agree and 5- strongly agree). To avoid any bias from the respondents, all the statements used to measure the teachers' perceptions of their teaching practices were positively worded. As displayed in Table 7.2, the consensus agreement and the mean scores show a more positive approach toward or perception of constructivism. The teachers show a more positive approach to statements relating to instructional practices that aim to help students to understand the mathematical concepts to which they are introduced. Their level of agreement with statements that help students to be innovative, creative and flexible in their thinking was lower than those which help students to understand the concepts. For example, all the teachers indicate that they review their students' knowledge and use a variety of teaching methods in their teaching; they also indicate that it is important that students follow routine instructions from the teacher and remember the correct procedure that they must follow to solve mathematical problems. However, the consensus agreement with students developing their own questions and methods of solving these questions was on the low side.

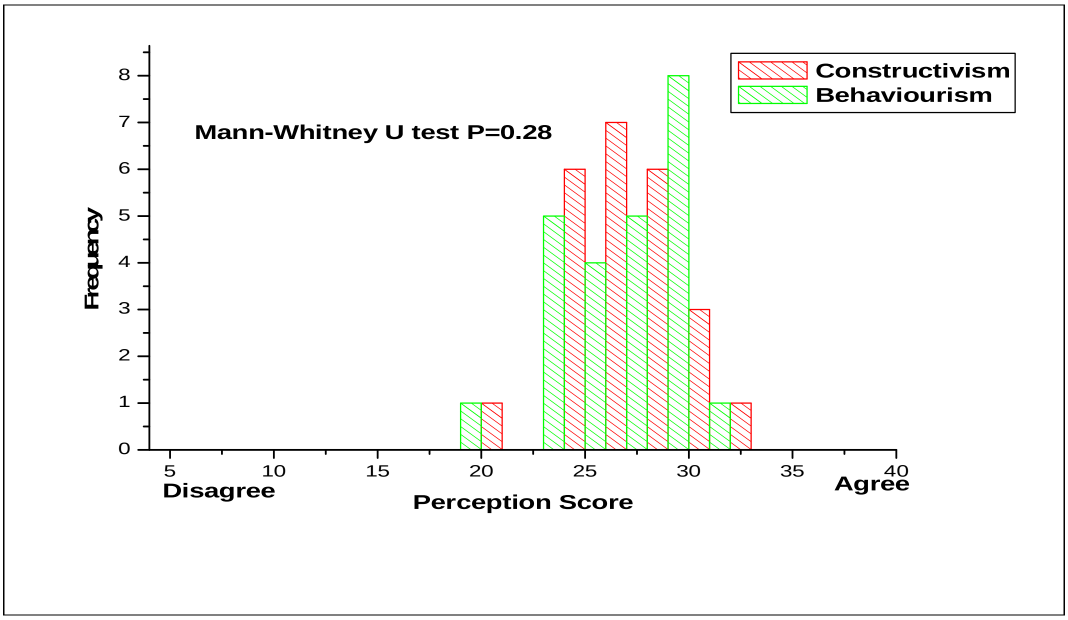


Figure 7. 3: Teachers Perceptions of their Teaching

To ascertain whether there is any statistical difference between teachers' perceptions of their teaching practices in relation to constructivism and behaviourism, the questions in each category were aggregated to give an overall score for each teacher, producing a range of between 4 and 40, indicating a constructivist or behaviourist attitude; 40 was the highest. As seen from Figure 7.3, the median constructivist score was 27, which was very positive; so was that of behaviourism, with a mean score of 26. From both Table 7.2 and Figure 7.3 it is clear that, although the majority of the teachers indicate their agreement with the constructivist approach to teaching and learning, the majority of was also strongly in agreement with the behaviourist approach to teaching. The results of a statistical test *(Mann-Whitley U test, P=0.28)* show that there is no statistical difference between teachers' perception of their teaching in relation to constructivist and behaviourist teaching practices.

In summary, the results from this study show that, inasmuch as the teachers acknowledge the importance of a student-centred approach to teaching, the majority were more likely to combine both constructivist and behaviourist teaching practices. The findings suggest that teachers' perception of their teaching practices is complex as they hold different views about the teaching and learning of mathematics. That is, although the majority follow a constructivist view of mathematics teaching, which is consistent with the national curriculum requirements, they also consider the behaviourist approach to the teaching of mathematics to be equally important. Previous studies have found that the use of a student-centred approach to teaching mathematics has been completely ignored in most mathematics classrooms (Fletcher 2005 and Adentunde 2007). The current study has not found any significant difference in choice between teacher-centred and student-centred approaches to the teaching of mathematics.

7.7 Students' Perceptions of their Learning Experiences

To survey students' perceptions of their learning experiences, the students were asked to rate their perception of 10 items. The items have been categorised into active (constructivist) and passive (behaviourist) learning experiences (see Table 7.3 and Figure 7.4).

Table 7. 3: Students Perceptions of their Learning Experiences (N=358)

Strategies	Statement	Percent	Type
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with my colleagues	90	Agree
	I compare different methods used to solve questions	87	Agree
	I ask the teacher questions when I do not understand	87	Agree
	I look for different ways to solve problems	75	Agree
	I make my own questions and methods	61	*
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	99	Agree
	I copy down the method from the board or textbook	92	Agree
	I attempt easy problems first to increase my confidence	91	Agree
	I only attempt questions I am told to do	78	Agree
	I work on my own	75	Agree

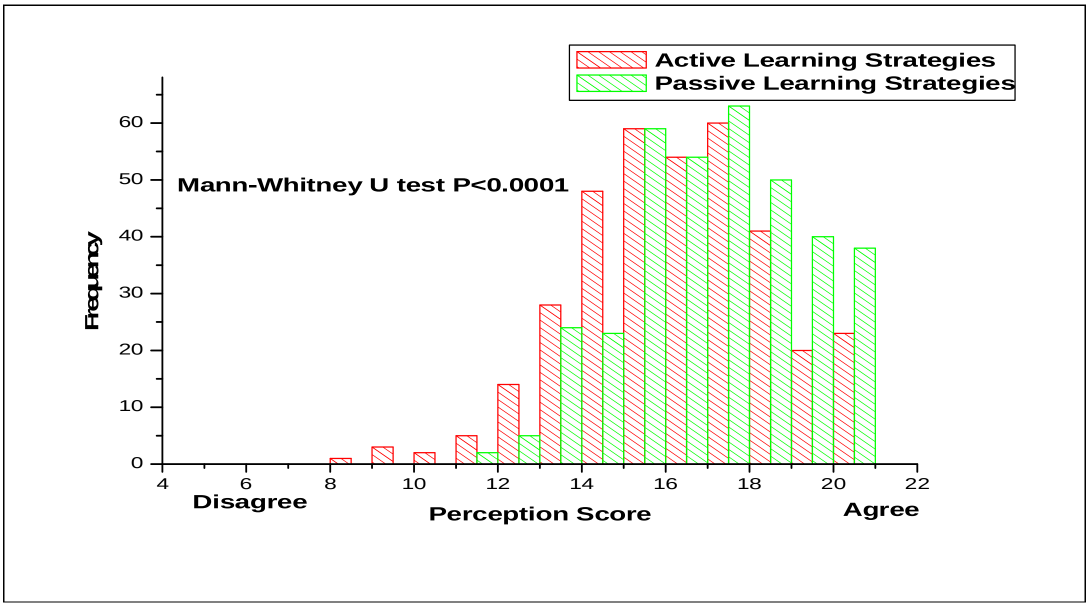


Figure 7. 4: Students Perceptions of their Learning

Table 7.3 shows that students experience or learn mathematics differently. The most common experiences or learning strategies that students report could be described as passive. The majority of the students report that they listen while the teacher explains, follow instructions, memorise rules and procedures. The results also show that the learning experiences of the majority of the students are controlled by the teacher. Additionally, a significant proportion of the students also indicate that they favour or use active learning strategies. Similar to the analysis of the teachers' perceptions of their teaching practices, the questions in each category were aggregated to give an overall score for each student's responses, which resulted in a range of 4 to 20. The median score for active learning strategies was 15. 8 and that of passive learning strategies was 16.6, which portrays a positive perceptional disposition towards both techniques. However, Figure 7.3 shows that the students were more likely to indicate they have had more (*(Mann-Whitley U test, P<0.0001)* behaviourist learning experiences than constructivist.

In summary, the key opinion or voice from the students' perceived learning experiences is that they appreciate working in groups and following the teacher's procedures to develop new knowledge and an understanding of mathematics concepts. Students' learning experiences could be described as a *mixed bag,* incorporating both active and passive learning experiences, although they are more likely to use passive learning strategies. These results provide an insight into how students learn and experience mathematics which is consistent with the findings from teachers' perceptions of their teaching practices. The recognised benefits of combining active and passive learning strategies is that they help students to structure their learning by following the teacher's instructions and also take responsibility for their own learning by actively participating in the teaching-learning process (Lim 2007).

These learning skills agree with those described by Mathews (1997) as necessary to promote students' learning, as there are still some mathematics concepts that students cannot learn alone and which require the help of a knowledgeable adult. In general, students' perceptions of their learning goes beyond the principle of constructivism, as they see the teacher's role as more than a facilitator and guidance from the teacher cannot be underestimated or ignored completely.

7.9 Students' Perceptions of their Teachers' Teaching

In addition to establishing teachers' perceptions of their own teaching practices, students were also asked to rate their perception of 10 items relating to their teachers' teaching (see Table 7.4 and Figure 7.5).

Table 7. 4: Students' Perceptions of their Teachers' Teaching (N=358)

Climate	Statements	Percent	Type
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90	Agree
	The teacher asks us to compare different methods for solving questions	87	Agree
	The teacher encourages us to make and discuss mistakes	84	Agree
	The teacher asks us to work in pairs or small groups	77	Agree
	The teacher encourages us to invent and use our own methods	54	*
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97	Agree
	The teacher asks us to work through practice exercises	94	Agree
	The teacher shows us which method to use and then asks us to use it	92	Agree
	The teacher tells us which questions to attempt	92	Agree
	The teacher expects us to follow the textbook closely	74	Agree

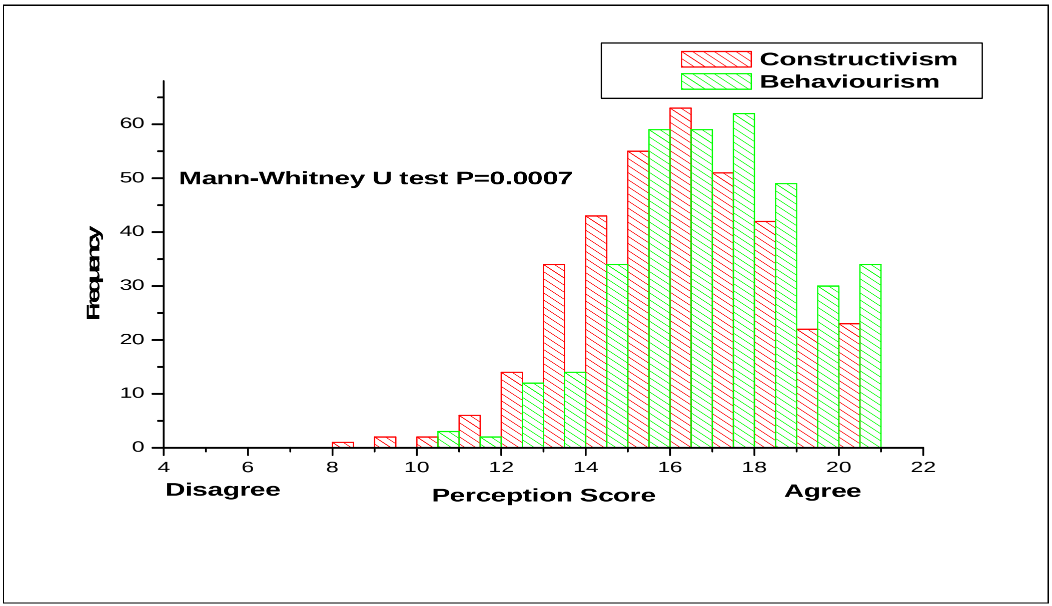


Figure 7. 5: Students Perceptions of their Teachers Teaching

The results show that, in general, students agree that their teachers are most likely to use both teacher-centred and student-centred approaches, which is consistent with the teachers' reports of their teaching practices. For example, similar to the responses from the teachers' questionnaire, the majority of the students report that the teacher tries to explain things carefully to prevent them from making mistakes. In addition, the majority of students indicate that the teacher tells them which method to use and this is consistent with teachers' perceptions of their own teaching practices.

However, there are few differences between teachers' and students' responses. Although there was no significant difference between teachers' reported practices in relation to constructivism and behaviourism, students were significantly (*Mann-Whitney U test, P=0.0007)* more likely to choose behaviourist teaching practices as the most frequently used methods by their teachers. Similarly, the results displayed in Table 7.4 show that the consensus percentages of students who indicate that their teachers use a teacher-centred approach is higher than the consensus percentages of those who indicate their teachers use a student-centred approach to teaching. In summary, the results have shown that students reported both teacher-centred and student-centred approaches to teaching are used by their teachers; however, the use of teacher-centred approaches was statistically significant, as compared to student-centred approaches. Students ascribe higher percentages to teacher-led activities than student-led activities.

7.10 Summary

This chapter has presented the results and analysis of the survey data from the questionnaire administered to the mathematics teachers and students in the 12 selected schools. In general, the analysis and results of the data from the questionnaires given to students and teachers provide an insight into the first (*What teaching methods are used by mathematics teachers?*), fourth (*What are students' perceptions of their teachers' teaching practices?*) and the fifth (*What are students' experiences of being taught mathematics?*) research questions.

The findings suggest that teachers use different teaching methods and their perceptions of their teaching and teaching priorities are consistent with the national curriculum guidelines. The majority of the teachers report that they use student-centred teaching methods. In addition, the results show that students' learning experiences are controlled by the actions or lack of action of the teacher. The key findings from the teachers' and students' questionnaires show that the teacher-centred approach to teaching is predominant, as the majority of the teachers indicate that they direct most of the classroom activities. Also, the majority of the students indicate that they listen and follow the teacher's instructions; these results were consistent with teachers' perceptions of their teaching and how they perceive their students' learning. However, despite the fact that the perceived teaching and learning strategies were directed mainly by teachers activities, the results show that students have experienced a student-centred approach to teaching and learning whereby they have had the opportunity to work in groups and discuss their work with colleagues.

This chapter has presented teachers' and students' perceptions of the teaching and learning strategies used, however, understanding how mathematics is taught and learned goes beyond establishing these views. It is with this approach that teachers' and students' perceptions of their teaching and learning and their actual teaching and learning practices are compared in Chapter 8, in which both quantitative and qualitative data sets are combined to provide a holistic picture of the situation.

Chapter 8

Individual Case Analysis

8.1 Introduction

In Chapter 7, the results and findings regarding teachers' and students' perceptions of their classroom practices were presented. However, one of the major critiques of educational research has been the failure to locate conceptions and measures of classroom quality and effectiveness within everyday classroom processes of teaching and learning (Jansen 1995). This chapter therefore takes the present study further than teachers' and students' perceptions by examining actual practices in mathematics classrooms.

The results of the quantitative and qualitative data analysed from the four individual case study schools is therefore presented. The unit of analysis in this chapter is the individual case study schools and detailed discussions about the findings and interpretation of the quantitative and qualitative data from each school are presented. The reason why individual case study schools are used as the unit of analysis is to take an in-depth look at each case to identify the common themes from each, which will be integrated to provide a holistic picture of the overall situation.

The chapter is sub-divided into four sections and each section is devoted to a case. Each sub-section starts with a demographic description of the school, including its student population and teachers' qualifications, after which the results and the findings from each school are presented and discussed. The analysis and presentation of the results are guided by the study research questions, which include:

1. What teaching methods are used by mathematics teachers?
2. Why do mathematics teachers use these teaching methods?
3. Is there any relationship between teachers' perception of their classroom practices and what they actually do in class?
4. What are students' perceptions of their teachers' teaching practices?
5. What are students' experiences of being taught mathematics?

8.2 Case Study School A

Background School Information

School A is a co-educational rural school which was established in 2000. Student enrolment during the 2009/2010 school year (when the study was conducted) was 127, 51.2 percent males and 48.8 percent females. The school had five teachers in total, three males and two females. Of these five teachers, four were trained teachers (two male and two female trained teachers) and one was untrained. There were two mathematics teachers in this school and both teachers were trained teachers. However, none of teacher was a qualified mathematics teacher, but they studied mathematics as a core subject during their teacher training programme.

Results from the Teachers' Questionnaire

The results from the teachers' questionnaire from this school indicate that both teachers of mathematics had similar perceptions with regard to their main priority when teaching mathematics. They indicate that their main priority when teaching is to adequately prepare their students to sit their Basic Education Certificate Examination, since schools are ranked according to their students' performance in this examination. Both teachers indicate that they often used a teaching method that promotes students' participation in the teaching-learning process.

One teacher has indicated that he uses the activity method because he wants to encourage students' understanding and help students to become actively involved in the teaching-learning process. The other teacher suggests he uses different methods to suit the needs and objectives of each topic. In addition, both teachers state that they start each lesson by reviewing their students' existing knowledge. Also, the two teachers claim that making mistakes is something they encourage their students to avoid and they try to give clear explanations to students in order to prevent them from making mistakes.

Both teachers indicate that they tell students which question to answer and which method to use when solving problems. However, both teachers also claim that they encourage their students to look for alternative method of solving problems and also motivate students to work in groups and discuss their work. Nevertheless, one teacher has stated that he sometimes uses the lecture method when presenting some mathematical concepts. He further adds that he normally uses the activity and demonstration method to increase students' understanding of the concept being presented. In general, teachers' perception of their teaching in this school is consistent with the results from the survey data from the 12 schools. The results establish that teacher-centred and student-centred approaches are used and students' learning experiences are controlled by the teacher, although students are sometimes encouraged to create new knowledge by discussing their work with their peers.

Results from the Students' Questionnaire

Similar to the analysis of the survey data from the 12 schools, the data from the students' questionnaire in this case study school was analysed under two main themes: students' perceptions of their learning experiences and students' perceptions of their teachers' teaching. This section therefore presents the results and analysis of the quantitative data from the 32 students who completed the questionnaire in this school.

Students' Perceptions of their Learning Experiences

In order to survey students' perceptions of their learning experiences in this school, the 32 students were asked to rate 10 items relating to how they learn mathematics. The items were categorised into two groups: passive learning strategies associated with behaviourism and active learning strategies associated with constructivism. Table 8.1 presents the mean ratings and percentages of consensus agreement or disagreement pertaining to the responses from the students in this school and the responses from the total number of students who completed the questionnaire.

Table 8. 1: Students' Perceptions of their Learning Experiences (School A)

Strategy	Statement	All Schools (n=358)		School A (n=32)	
		Percent	Type	Percent	Type
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with my colleagues	90	Agree	100	Agree
	I compare different methods used to solve questions	87	Agree	94	Agree
	I ask the teacher questions when I do not understand	87	Agree	91	Agree
	I look for different ways to solve problems	75	Agree	84	Agree
	I make up my own questions and methods	61	*	91	Agree
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	99	Agree	97	Agree
	I copy down the method from the board or textbook	92	Agree	94	Agree
	I attempt easy problems first to increase my confidence	91	Agree	87	Agree
	I only attempt questions I am told to do	78	Agree	79	Agree
	I work on my own	75	Agree	100	Agree

From table 8.1, it is interesting to note that the consensus agreements of the 32 students in this school were higher than the consensus agreements from the total sample of 358 students who completed the questionnaire. Hence, there were some differences in the responses from the students in this school as compared to the responses from the total sample. In this school, students' perception of their learning experiences was evenly distributed among the active and passive domains. Unlike the responses from the total sample, there was no significant difference (*Mann-Whitney U test, P=0.72*) between students' learning experiences, as students ascribed higher percentages to both active and passive learning strategies, showing positive perceptional disposition to both strategies.

In general, the results from Table 8.1 show that students' learning experiences are influenced by the teacher directed activities whereby students listen and follow the teacher's instructions. Furthermore, the results show that tasks are individually undertaken, as all the students report that they work alone and majority indicate that they listen while the teacher explains. However, as outlined above, there was no significant difference between their choice of active or passive learning strategies, as most students claim that they do not only follow the method presented by their teacher, but also look for different ways to solve problems. These findings therefore suggest that students' active participation in the teaching-learning process is necessary to stimulate conceptual understanding; however, the role of the teacher in shaping students' learning experiences cannot be underestimated.

Students' Perceptions of their Teachers Teaching

In addition to establishing teachers' perception of their own teaching, the 32 students who completed the questionnaire in this school were also asked to rate their perceptions of ten items relating to their teachers' teaching. The first five items represent the student-centred approach to teaching and the last five represent the teacher-centred approach (see Table 8.2).

Table 8.2: Students' Perceptions of their Teachers' Teaching (School A)

Climate	Statement	All Schools (n=358)		School A (n=32)	
		Percent	Type	Percent	Type
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90	Agree	100	Agree
	The teacher asks us to compare different methods for solving questions	87	Agree	94	Agree
	The teacher encourages us to make and discuss our mistakes	84	Agree	97	Agree
	The teacher asks us to work in pairs or small groups	77	Agree	94	Agree
	The teacher encourages us to invent and use our own methods	54	*	81	Agree
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97	Agree	97	Agree
	The teacher asks us to work through practice exercises	94	Agree	94	Agree
	The teacher shows us which method to use and then asks us to use it.	92	Agree	97	Agree
	The teacher tells us which questions to attempt	92	Agree	94	Agree
	The teacher expects us to follow the textbook closely	74	Agree	87	Agree

As before, the results from this school present a different picture to the results from the total sample, with the majority of the students describing their teachers' teaching as both teacher-centred and student-centred. The differences in these consensus agreements for teacher-centred and student-centred approaches to teaching in this school compared to the percentages of consensus agreements in the total sample are striking, but the proportion of students in this school to the total sample is relatively small. In both cases, the mean percentage score for the teacher-centred (93.8) approach was proportionately similar to that of the student-centred approach (93.2) and there was no significant difference (*Mann-Whitney U test, P=0.99)* between students' perception of their teachers teaching in relation to the two teaching approaches. This implies that inasmuch as students perceive their teachers' teaching to be teacher-centred, they also consider their teachers to be proactive in creating a receptive classroom environment in which students are given the opportunity to be actively involved in the teaching-learning process.

Classroom Observation

I observed two lessons in this school as the two mathematics teachers only agreed to be observed once and each lesson lasted for 35 minutes. This section will first present a description of the lessons observed, followed by the teaching and learning strategies adopted and the type of interactions which were noted during the lesson.

Descriptions of the Lessons Observed

In this school, JHS 1 and JHS 2 classes were observed and the two lessons were: the perimeter of a regular polygon, equations and inequalities. The JHS1 class comprised 34 students, 20 boys and 14 girls, and the JHS 2 class was composed of 36 students, 17 boys and 19 girls. A brief overview of the lessons is presented in the subsequent sections.

Lesson 1: Perimeter of a Regular Polygon

To introduce the first lesson, the teacher reviewed the existing knowledge of individual students by asking the students the meaning of a regular polygon and the types of regular polygon (see Table 8.3). Three students put up their hands to answer the teacher's question and one was called to answer the question, after which a student was called to the chalkboard to draw a six sided polygon (hexagon). The teacher then introduced the topic for the day and gave the students the procedural steps to find the perimeter of a regular polygon. The teacher made the students aware that the perimeter of a regular polygon with **N** equal sides and **L** (length of the sides) is found by ***Perimeter = NL***.

The teacher then solved one example using the formulae and then asked the students to copy the solution into their books and follow the same procedure to solve a series of questions written on the board. The teacher advised the students that they were free to work individually or with a colleague. Although there was no discussion among students, as they were doing individual work, they were seen to compare answers with colleagues after completing a set of questions.

Table 8. 3: Observed Teaching Practices in Lesson 1

Teacher (T): What is a polygon?
Student (S): A polygon is a figure with many sides
T: A polygon is any sided shape with straight lines
T: What are the different types of polygons that we looked at?
Ss: Pentagon, hexagon, octagon, nonagon, decagon
T: What is a perimeter?
Ss: The distance around a figure
T: Is that right?
Ss: Yes Sir
T: Ok today we want to look at how to find the perimeter of a regular polygon
T: To find the perimeter of a polygon you have to find the sum of all the sides of the polygon
T: Teacher drew a hexagon of sides 13cm and asked the students. "What is the sum of all the sides?"
Ss: 78
T: So we can say that the formula for finding the perimeter of a regular polygon is ***N*L*** where N is the number of sides of the polygon and L is the length of the sides
S: Sir why N*L?
T: Because we have N number of sides and L lengths
T: The teacher then drew a pentagon with a length of 25cm on the board and asked the students to find its perimeter
T: After waiting for about two minutes, the teacher asked what the answer is.
Ss: 125cm
T: Teacher drew a decagon of sides 10cm and called *Alex* to come to the board to calculate its

perimeter.

Alex: Alex wrote 100cm on the board and went back to his seat.

T: Is he right?

Ss: Yes

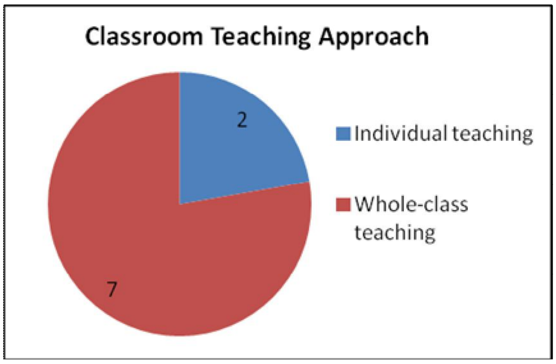
T: The teacher drew an octagon of with 8cm sides on the board and asked students to find its perimeter as he went round to assist and guide students.

T: What is the answer?

Ss: 64cm

T: Ok copy the following questions as homework

Table 8.3 demonstrates a sequence of teacher and student led activities through which the lesson was taught and learned. The teaching approach followed in this lesson was dominated by a teacher-centred approach, with some elements of the demonstration and discussion methods of teaching. That is, the lesson followed a sequence during which the teacher asked a question and students responded in chorus or a student was called to answer the question. Students' participation in this lesson was therefore characterised by students answering the teacher's questions and the asking of questions by students. The teacher's questions and students' responses to these questions were therefore used to establish how the classroom teaching was organised. Choral responses from students were used to represent whole class teaching and individual responses were used to indicate individual class teaching (Mereku 1995). Moreover, the amount of speech from the teacher and students was further used to examine students' level of participation in the teaching-learning process (see figures 8.1 and 8.2).



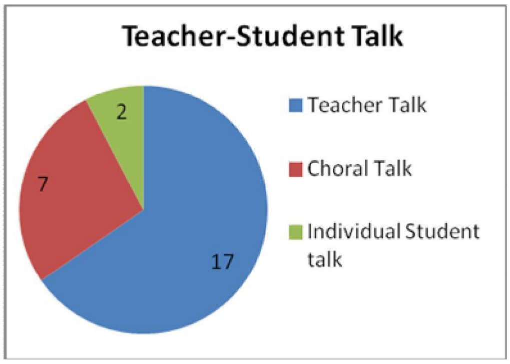


Figure 8. 1: Classroom Teaching Approach **Figure 8. 2: Teacher-Student Talk**

Figure 8.1 shows that students' participation and communication with their teacher normally takes place through contact with the whole class, as seven out of nine student responses in this lesson were choral. Similar to the findings of Mereku (2003), the majority of the students participated by providing choral responses to their teacher's question and small-group or group work was not evidenced in this lesson. In addition, the finding from Figure 8.2 supports Stigler *et al.*'s (2000) assertion that the proportion of speech by the teacher and students in most mathematics classrooms is 8:1. Of the 22 interactions which were recorded in this lesson, the ratio of speech by the teacher and individual learners was 8.5:1 and this result is also consistent with the survey results in this school, as most of the students reveal that they listen while the teacher explains.

Lesson 2: Equations and Inequalities

The second lesson started by correcting students' mistakes in their previous homework. The teacher wrote the homework questions on the board and called students in turn to come to the board and solve the questions by explaining to their colleagues how they arrived at their answers. Students' mistakes and misconceptions were identified by the teacher and were corrected. After correcting the students' homework, the teacher then informed the students that they would be looking at the concept of inequalities and drew the students attention to inequality signs that they have learnt before ($<$; $>$; $\leq$; $\geq$). The teacher took some time to explain the meaning of these symbols to the students and revealed that an equation with any of these signs indicating how one expression is related to the other is called an inequality. The teacher then solved a question on the board and gave the students a task to perform. The students first had to write down five examples of inequalities and try to solve the inequalities that they produced. The teacher then moved from one student to another, assisting and guiding individual students (see Table 8.4).

Table 8. 4: Observed Teaching Practices in Lesson 2

T: Take your homework books (the teacher started writing the homework questions on the board)
T: "Solve the first question". This asked students to solve the equation 2x+3=x+6
S: A student was called to the board to solve the second problem which asked students to solve the equation 2(x+3) = x+16. The student wrote 2x+6=x+16, therefore x= 10
T: Is that correct?
Ss: Yes sir
T: The teacher called another student to solve the equation ½ (3x+4) = x+6
S: The student wrote 3x+4=2x+6, therefore x=2
T: Is that correct?
Ss: No
T: The teacher quickly wrote the correct solution on the board and asked students to copy
T: We are moving to a new topic (while writing inequalities)
T: Teacher drew students' attention to the inequality signs which were introduced in the previous lesson
T: The teacher then wrote the following on the board and said "These are all examples of inequalities": $2x \geq 6; \quad 3x \leq x - 8$.
T: The teacher called a student to give an example of an inequality
S: The student then said "$x > 5$"
T: Is this an inequality?
Ss: Yes sir

T: clap for him

T: The teacher wrote on the board “Solve the inequality: $2x-1 \geq 5+3x$”

T: So what did we said about solving equations?

Ss: You group like terms

T: The teacher wrote $2x-3x \geq 5+1$

T: Do you understand?

T: Yes sir

T: So what do we do next?

S: You simplify

T: So what do we write?

Ss: $-x \geq 6$

T: “When you divide an inequality by a negative number the inequality sign changes”. He wrote $x \leq 6$.

T: Do you understand?

T: clap for him

T: The teacher wrote on the board solve the inequality: $2x-1 \geq 5+3x$.

T: So what did we said about solving equation?

Ss: You group like terms

T: The teacher wrote $2x-3x \geq 5+1$.

T: Do you understand?

T: Yes sir

T: So what do we do next?

S: You simplify.

T: So what do we write?

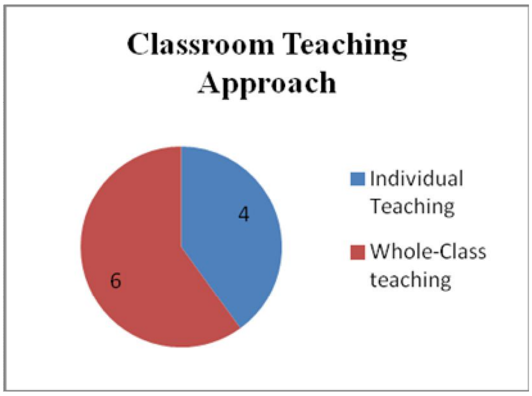
Ss: $-x \geq 6$

T: “when you divide an inequality by a negative number the inequality sign changes and wrote $x \leq 6$.

T: Do you understand?

Ss: Yes sir

T: The teacher wrote three examples on the board and asked the students to work in their books.



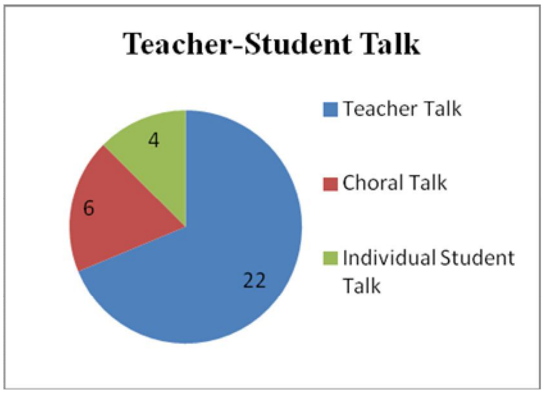


Figure 8. 3: : Classroom Teaching Approach **Figure 8. 4: Teacher-Student Talk**

From Table 8.4, it is clear that the instructional practice used during this lesson followed a teacher-centred approach, although the teacher incorporated this with the demonstration and discussion methods. Most of the activities were teacher led and students' participation in the teaching-learning process was characterised by answering the teacher's questions and chorus responses in support of the teacher's answer. Figure 8.4 establishes that the teaching approach used was therefore characterised by whole-class teaching, with six of the 10 responses being choral.

However, the individual teaching approach was incorporated with a whole-class teaching approach, although the proportion of choral responses was higher than individual responses. The result from this lesson is therefore consistent with that of lesson one, as the teaching-learning process was highly influenced by the teacher's actions. This is evidenced in Figure 8.4, where the ratio of speech by the teacher and individual students 5.5:1. However, the ratio of speech by the teacher and students is far lower than Stigler *et al.'s* (2000) ratio, as more students were given the chance to present their work on the board. The results therefore suggest that giving more students the opportunity to present and participate in the teaching-learning process reduces the teacher-student talk ratio, which is one of the underpinning principles of the new and improved instructional practices distinguishable in the literature.

In general, the above results suggest that the focus and direction of the two lessons were determined by ideas from students, through the review of their existing knowledge. Both teachers used teacher-centred and student-centred approaches to presenting the concept to be learnt. However, the teacher-centred approach dominated both lessons, as the teacher did most of the talking and students were seen to be copying notes with minimal interaction; this is consistent with the findings of Fletcher (2005). In both lessons, students were seen to follow the procedure dictated to them by their teacher in order to solve a series of questions and there was not much active participation among students. It was also observed that paying attention, listening to the teacher and using the teacher's approach to solving questions were paramount to the students. In both lessons, the resources used were the textbook and the chalkboard; no concrete teaching-learning materials were available to the students to help develop their conceptual understanding of the concept presented. For example, throughout the entire lesson the main resource used was the teacher's textbook and even though students had copies of the textbooks, these were never used.

Interviews

In this school, the two mathematics teachers consented to take part in the study; they completed the survey instruments and their lessons were observed. However, only one teacher was interviewed, as the other teacher declined. This section therefore presents the results of the discussion with the teacher (see Table 8.5), and also the four students who were interviewed.

Teacher A Interview Report and Analysis

Table 8. 5: Interview Report of Teacher A

Interviewer (I): How do you normally start your lessons? **Teacher A (TA):** Hmm the normal process. I start by reviewing students' related knowledge. **I**: So why do you review students' related knowledge before starting the actual lesson?

TA: That helps me to know what the students know so that I can build on it.

I: How will you define teaching well?

TA: Teaching well relates to the ability to present a particular topic in a way that promotes students' understanding of the particular concept. That is, teaching well revolves around reviewing and building on students' related knowledge to the topic in question, evaluating students' understanding through a series of activities and giving feedback.

I: So under what circumstances would you be assured that you have taught well?

TA: Ok, you know many students find the subject difficult and presenting the concept in a manner that promotes students' understanding and active participation is paramount. One can say he has taught well based on the feedback he/she gets from the students.

I: What teaching methods do you normally use in your lessons?

TA: Demonstration and activity methods.

I: What do you think is/are the best method(s) of teaching mathematics?

TA: Hmm the method used in teaching a particular topic depends on the topic under consideration. I normally use the activity and demonstration methods, as these methods motivate and develop students' interest. The combination of a variety of teaching methods helps promote students interest, and motivates students to develop a conceptual understanding of a mathematical concept.

I: What are your main priorities when teaching mathematics?

TA: Promoting students' understanding and preparing them for their final examination are two main priorities. But you know, although promoting students' understanding is important, the mathematics curriculum does not give enough room for this as it is results-oriented and we are forced to concentrate on finishing the syllabus rather than motivating and helping students to develop an interest in the subject.

I: In your view what is the best way (s) for students to learn mathematics?

TA: Paying attention, participation and practicing to improve their confidence levels and overcoming their maths anxieties.

I: So how do you promote students' participation in class?

TA: Through questioning, the use of appropriate teaching and learning materials (TLMs) to help students explore different ways of solving mathematics problems.

The interview report of Teacher A, who has nine years experience as a teacher and four years experience as a mathematics teacher, shows that the teacher sees the teaching and learning of mathematics as the 'use of old knowledge in developing new knowledge'. For example, he reports that the 'best way' to teach mathematics is to build on students existing knowledge and use a variety of teaching methods to encourage students' active participation. The teacher cited activity and demonstration methods as the main methods that he uses during mathematics lessons, as these techniques boost students' active participation and understanding. The teacher explains that active participation in the teaching-learning process and practice helps to overcome mathematics anxieties and promote students' interest in the learning of mathematics, as highlighted by Kong *et al.* (2003).

The interview result is consistent with the classroom observation result to some extent, as the classroom observation results and the interview results establish that the teacher uses the demonstration method. Also, in both cases, it was revealed that students' participation in the teaching-learning process is characterised by the answering of the teacher's questions. However, it is interesting to note that, despite the teacher saying that he encourages "*the use of appropriate teaching and learning materials (TLMs) to help students explore different ways of solving mathematics problems",* the lesson observation result confirms that there were not enough TLMs, with the exception of the teacher's textbook.

Students' Interview Reports and Analysis

In this particular school, I interviewed four students, two from each of the classes observed (see Table 8.6). The interview responses were categorised under four headings: reasons for learning mathematics, students' participation, students' views regarding what it takes to be successful in mathematics and students' preferred learning styles.

Table 8. 6: Students' Interview Responses- School A

Interview Questions/Themes	Descriptions and examples from interview data
How often do you learn mathematics and why?	Core subject – it is a compulsory subject Occupational aspirations- relevant to what the kind of job they want to do in future Selection- they need to pass their maths examination for admission into Senior High School (SHS) Practice – so that they can understand Confidence – learning helps improve their confidence Not good at maths – think practicing every day will help them
If you know the answer to a question will you volunteer to answer it?	Yes – but only when they are confident the answer is correct Yes – but only when they are called by the teacher Sometimes – when they want to test their understanding No- because they are not good at mathematics and think their answers may wrong.
What happens if you give a wrong answer?	Correction – the teacher will correct them Mocked- their colleagues will laugh at them Rethink – they will rethink the question to see why they got it wrong.
How do you feel when you give a wrong answer?	Shy – as their colleagues may mock them Unhappy- it reduced their confidence level Uncomfortable- will look like they have not been paying attention in class
What does it take to be successful in mathematics?	Practicing- following teachers' methods Attention – paying attention in class and following the teacher's instructions Sharing Ideas- working together with colleagues Methods – looking for different methods to solve a problem
Why do you prefer to learn alone?	Confidence- feels confident working alone
Why do you prefer to learn in groups or with colleagues?	Correction – they can be corrected by their colleagues Confidence- they are not confident and working with colleagues boosts their confidence level Compare- so that they can compare notes and ideas

Why Students' Learn Mathematics

Each student was asked to provide a number of reasons why they learn mathematics. The responses were collated and categorised into five different themes: core subject, occupational aspirations, selection to senior high schools, practice and confidence (see Figure 8.5).

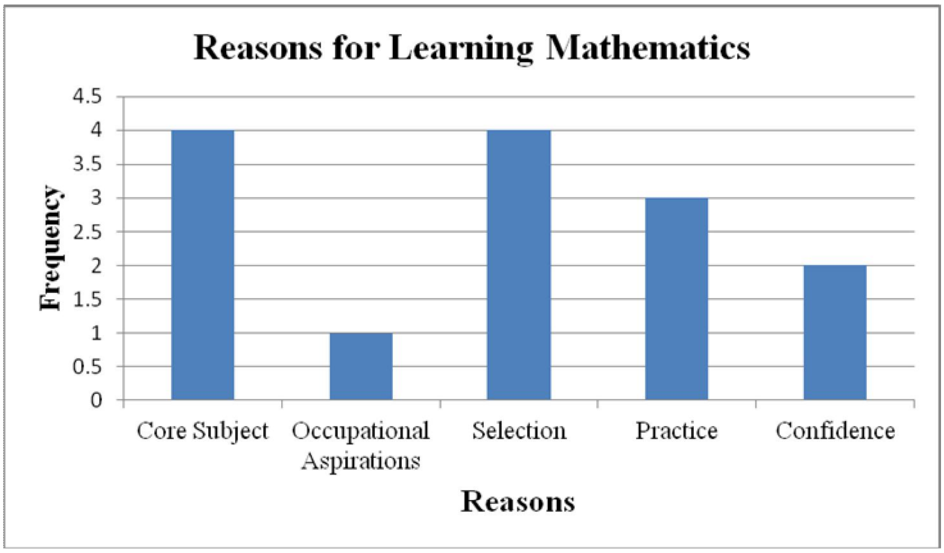


Figure 8. 5: Students' Views about why they Learn Mathematics-School A

There are different reasons why students learn mathematics and this is evident in Figure 8.5. All the four interviewees indicate that they learn mathematics because it is a core subject. Also, all the interviewees give selection to senior high schools as one of the reasons why they learn mathematics. They report that they need a good grade in mathematics to gain admission to the best senior secondary schools. Moreover, two students reveal that they learn mathematics because they want to boost their confidence levels and one person states that she learns mathematics because she wants to be an engineer in the future.

It is therefore evident from Figure 8.5 that all the respondents are eager to attain good grades in mathematics to guarantee their places in one of the best secondary schools. This implies that students acknowledge the importance of mathematics, not only as a core subject, but also since they will need it for their future educational and occupational aspirations. This could possibly affect students' learning, since they will approach the subject as something they need to learn for its utilitarian benefits, not only for academic purpose (Ampadu 2009).

Students' Participation in Mathematics Lessons

Students' active participation in the teaching-learning process is an important factor in promoting effective teaching and learning. I have argued elsewhere (Ampadu 2011) that students' participation in the teaching-learning process is dependent on their enthusiasm and willingness to play an active role in the teaching-learning process. Information about students' views regarding their willingness to participate in the teaching-learning process was elicited by asking the interviewees about the likelihood of them volunteering to answer a question if they know the answer and what happens when they give a wrong answer (see Figure 8.6).

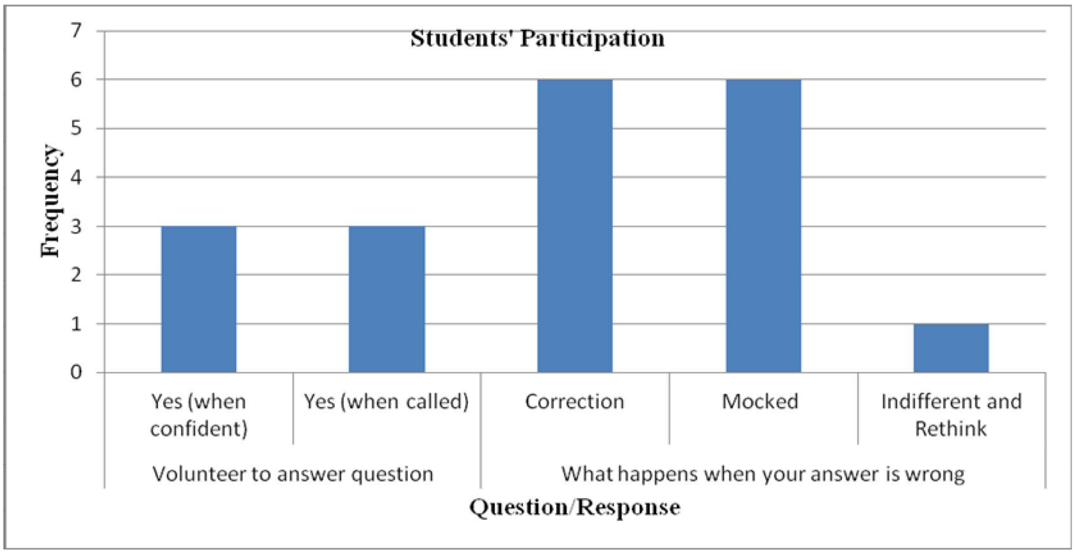


Figure 8. 6: Students' Willingness to Participate

The analysis of the interview data shows that all four interviewees expressed their willingness to answer questions in class when they know the answer. It is, however, interesting to note that, despite indicating their willingness to volunteer to answer questions, one interviewee reports that she will sometimes be willing to answer a question when she is confident. Another interviewee also reveals that he may not volunteer to answer a question since he is not good at mathematics and frequently gives wrong answers in class.

I further asked the interviewees what happens when they give a wrong answer, and all four responded that their teacher will correct them. Also, all the interviewees said that their colleagues will mock them when they give a wrong answer and one student indicated that he would rethink and answer the question again. The results therefore show that students' participation is, to a large extent, influenced by both personal and peer factors. In general, although students are willing and prepared to participate in the teaching-learning process, to a large extent the feedback they get from their colleagues influences their participation.

What It Takes to be Successful in Mathematics

One of the purposes of the individual interviews was to elicit students' views regarding what it takes to be successful when learning mathematics. The individual responses from the interviewees are categorised into four common themes and the categories are presented below in Figure 8.7.

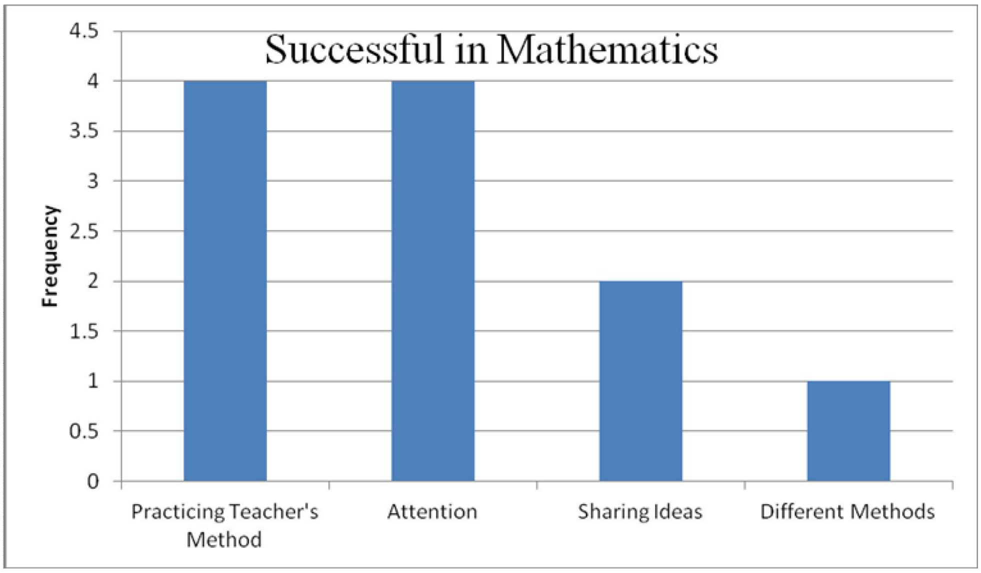


Figure 8. 7: What it takes to be successful in Mathematics

Figure 8.7 shows that students have differing views regarding what it takes to be successful when learning mathematics. The common themes which came out during the interviews were: practicing, paying attention in class, following the teacher's instructions and looking for different methods to solve problems. All four interviewees reveal that in order to be successful in mathematics it is necessary to practice the teacher's teaching methods and all report that one must pay attention in class and listen to the teacher's instructions. In addition, two of the interviewees confide that, apart from following the teacher's instructions, the sharing of ideas helps one to be successful when learning mathematics. Also, one of the interviewees explains that, to be successful in mathematics, one has to look for and use different methods when solving problems.

Figure 8.7 shows that, despite the interviewees' differing views regarding what it take to be successful when learning mathematics, it can be argued that the learning experiences of these students are to a large extent influenced and directed by the teacher. This suggests that these students rely on their teacher's methods to develop their understanding, without necessarily looking for alternative approaches to solving problems. However, it was also interesting to note that, despite the important role that the teacher plays in shaping students' learning experiences, students' active participation is considered paramount in developing new knowledge. For example, similar to the findings of Boaler (1998), the interview reports establish that success in mathematics goes beyond the mere imitation of the teacher's approach to sharing ideas with colleagues and finding different methods to solve problems.

Students' Preferred Ways to Learn

One of the main objectives of this study is to examine students' learning experiences. The last two questions in the interview protocol were used to solicit information regarding which learning method the students prefer and why they prefer such a method (see Figure 8.8).

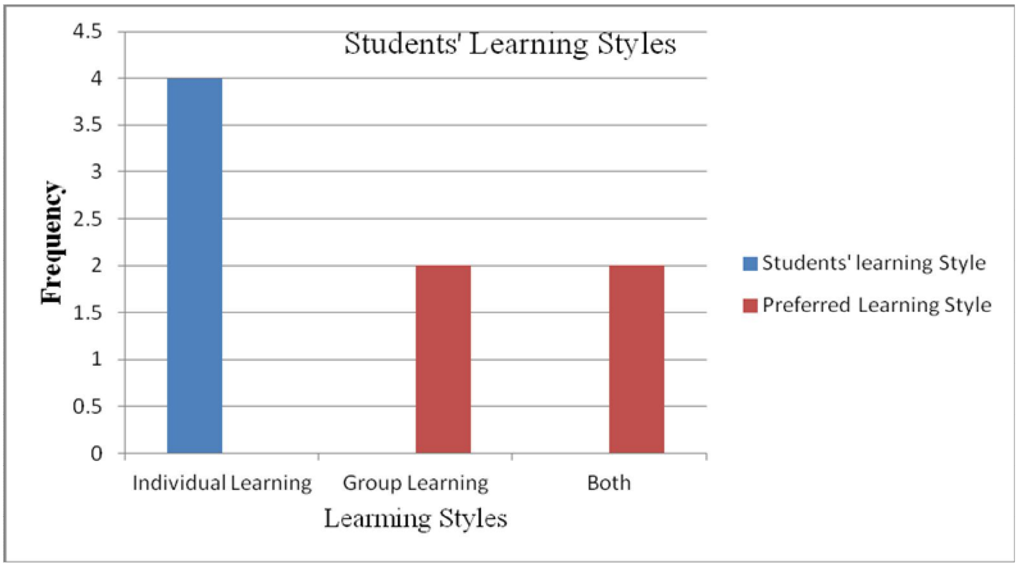


Figure 8.8: Students' Preferred ways of Learning

The results from the students' interview reports, as evidenced in Figure 8.8, suggest that students' experience and learn mathematics differently. All four interviewees report that they normally learn alone, while two interviewees confide that they prefer to learn in groups; two interviewees also indicate they prefer to learn alone and sometimes together. For example, one student explains that, although she normally works alone in class, she prefers working with her colleagues so that she can be corrected when she is wrong. Another student states that he works alone in class and works with his friends from other schools at home to gain new knowledge and ideas. He adds that group work is not encouraged in his school and the only time he can work with friends is when he is at home. Since individual students learn differently, this therefore calls for the use of different teaching methods to stimulate the individual student's desire to learn (Felder 1993).

Synthesis of Information

The analysis of the quantitative data from the questionnaire and the qualitative data from the classroom observations and the individual interviews has established that the instructional practices in both lessons follow a similar pattern and are mostly characterised by the teacher-centred approach. It has also been established that the three data sets provide different, but interrelated results about how mathematics is taught and learned. With respect to the teaching methods used by mathematics teachers, the different data sets reveal that teachers use different teaching methods. However, the interview report from the teachers has established that the choice of a particular method is influenced by the concept being introduced and all lessons begin with a review of students' related knowledge.

The results from the questionnaire show that students' learning experiences consist of listening, copying notes and following the teacher's instructions and procedures. However, despite the use of a teacher-centred approach, the observation results have established that both teachers encourage students' participation through questioning and occasional presentations on the chalkboard. This is supported by the data from the students' questionnaire regarding their perception of their teachers' teaching, as the majority of students report that their teachers use both methods of teaching. The results also establish that making mistakes is considered to be a negative way to learn mathematics and both teachers state that they always try as much as possible to prevent their students from making mistakes by giving them a step–by-step approach to follow when solving problems. The analyses of the quantitative and qualitative data from this school have provided some insights to help answer the five research questions of the study. However, the results from only one school (two teachers and 32 students) do not provide a holistic picture of the topic under consideration. The subsequent sections therefore examine the same issues from the perspective of three other schools.

8.3 Case Study School B

Background School Information

School B is a co-educational rural school located on the outskirts of the metropolis. The school was established in 2002 as a primary school and the junior high school was introduced in 2007 with only two streams, JHS 1 and JHS 2. School B is one of the two junior secondary schools in the locality. Student enrolment for the 2009/2010 academic year was 48, with 60.4 percent male and 39.6 percent female. The school had a total of six teachers; four male and two female, one untrained. The mathematics teacher handling the two classes was a trained teacher who studied mathematics as a minor subject at the undergraduate level.

Results from the Teachers' Questionnaire

The results from the mathematics teachers' questionnaire in this school reveal that the teacher uses a variety of teaching techniques. He has indicated that he often uses activity, demonstration and discovery methods when teaching mathematics. He also revealed that he sometimes uses group work, but never uses the lecture method during mathematics lessons. The teacher explained that he uses a variety of methods during lessons because the students have a poor background in mathematics and the use of different teaching methods helps to promote students' understanding.

The teacher also clarified that his main priority is to help students to understand and develop an interest in mathematics and encourage them to appreciate the importance of the subject. He said that preparing students to pass their examination is also important, but he thinks the individual student's ability to understand the mathematical concepts and skills presented is a prerequisite above all other objectives and priorities. In view of this, he teaches each topic from the beginning, assuming that his students know nothing, and uses a variety of methods when solving problems. He also encourages his students to ask questions and find different ways to solve problems. The results have therefore established that, similar to the findings of the survey results from the 12 schools, the teacher starts his lesson by reviewing his students' related knowledge and he acknowledges the importance of using different teaching methods in promoting students' understanding.

Results from the Students' Questionnaire

This section presents the results and analysis of the 30 questionnaires completed by the students. The questionnaires were analysed under two themes: students' perceptions of their learning experiences (see Table 8.7) and students' perceptions of their teachers' teaching (see Table 8.8).

Students Perceptions of their Learning Experiences

Table 8. 7: Students Perceptions of their Learning Experiences (School B)

Strategy	Statement	All Schools (n=358)		School B (n=30)	
		Percent	Type	Percent	Type
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with my colleagues	90	Agree	90	Agree
	I compare different methods used to solve questions	87	Agree	97	Agree
	I ask the teacher questions when I do not understand	87	Agree	90	Agree
	I look for different ways to solve problems	75	Agree	63	*
	I make up my own questions and methods	61	*	90	Agree
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	99	Agree	100	Agree
	I copy down the method from the board or textbook	92	Agree	100	Agree
	I attempt easy problems first to increase my confidence	91	Agree	90	Agree
	I only attempt questions I am told to do	78	Agree	90	Agree
	I work on my own	75	Agree	77	Agree

The results from this school show a significant difference in both the percentage ratings of strategies in this school and the total sample for all the items. The proportion of students who perceive their learning experiences to be passive in this school is greater than the proportion of students who perceived their learning experiences to be passive in the total sample. The results show that students' experience mathematics in a didactic way by following the teacher's methods and approaches to solving problems. That is, passive learning dominates the learning experiences of the majority of the students as they listen and follow the teacher's instructions and approaches to solving questions, with little or no innovation among these students. However, statistically there was no significant difference (*Mann-Whitney U test*, *P=0.21*) between students' perceptions of their learning in relation to active and passive learning experiences, which suggests that despite most of the respondents reporting passive learning strategies, active learning approaches are not completely ignored.

Students' Perceptions of their Teachers' Teaching

The fourth research question in this study seeks to understand how students' perceive their teachers' teaching. To achieve this, the students were asked to rate their perception of ten items relating to their teacher's teaching (See table 8.8).

Table 8. 8: Students' Perceptions of their Teachers' Teaching (School B)

Climate	Statement	All Schools (n=358)		School B (n=30)	
		Percent	Type	Percent	Type
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90	Agree	73	Agree
	The teacher asks us to compare different methods for solving questions	87	Agree	77	Agree
	The teacher encourages us to make and discuss mistakes	84	Agree	93	Agree
	The teacher asks us to work in pairs or small groups	77	Agree	63	*
	The teacher encourages us to invent and use our own methods	54	*	57	*
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97	Agree	97	Agree
	The teacher asks us to work through practice exercises	94	Agree	97	Agree
	The teacher shows us which method to use and then asks us to use it	92	Agree	97	Agree
	The teacher tells us which questions to attempt	92	Agree	93	Agree
	The teacher expects us to follow the textbook closely	74	Agree	97	Agree

It is evident from Table 8.8 that teacher-centred items received higher percentage scores than the student-centred items. For example, the majority (97%) of students agree that the teacher tries to prevent them from making mistakes by explaining things carefully and a greater proportion (93%) report that the teacher tells them which questions to do. Students' perceptions of their teachers' teaching was statistically significant (*Mann-Whitney U test, P=0.002*) and the students are more likely to consider their teacher's teaching to be teacher-centred. The results suggest that there is a variable atmosphere in which the teacher combines both teacher-centred and student-centred approaches. The implication of these skills of learning is that students will develop a greater procedural understanding of mathematics as compared to a conceptual understanding. This therefore calls for the creation of a more receptive classroom environment through the use of a variety of teaching methods that give students maximum learning opportunities (Boaler 2009).

Classroom Observation

I observed two lessons in this school and this section presents the results and analysis of the classroom observation data. This section is divided into two sub-sections: the first presents a description of the lessons observed and the second outlines the teaching and learning strategies observed in each lesson.

Description of the Lessons Observed

In this school, two lessons were observed in two different classes: JHS1 (comparing fractions) and JHS2 (grouped frequency distribution tables). The JHS 1 class comprised 25 students, 16 boys and nine girls, and the JHS 2 class was composed of 23 students, 13 boys and 10 girls.

Lesson 3: Comparing Fractions

The purpose of this lesson was to help students to develop an understanding of how to compare two or more fractions using the mathematical symbols ‘>’ and ‘<’ to which the students had been introduced in their previous lessons. The teacher started the lesson by reviewing students’ existing knowledge from their previous lesson and then went through the homework questions with students, correcting individual students’ misconceptions regarding the simplification of fractions. The teacher then introduced the students to the day’s lesson by informing them it would follow up what they had been studying for the past week (see Table 8.9).

Table 8. 9: Observed Teaching Practices in Lesson 3 (School B)

Teacher (T): Take out your homework books (*the teacher wrote the homework questions on the board)*
T: A lot of you made mistakes in simplifying the fraction $\frac{4}{16}$

T: The majority of you wrote $\frac{2}{8}$ as the final answer

T: Although $\frac{2}{8}$ is correct it is not a simplified form of the fraction in question

T: Can we simplify $\frac{2}{8}$ further?

Students (Ss): Yes sir

T: The teacher called a student to the board to further simplify the expression

Student (s): $\frac{1}{4}$

T: Ok that is good

T: The teacher called a student to the board to simplify $\frac{7}{21}$

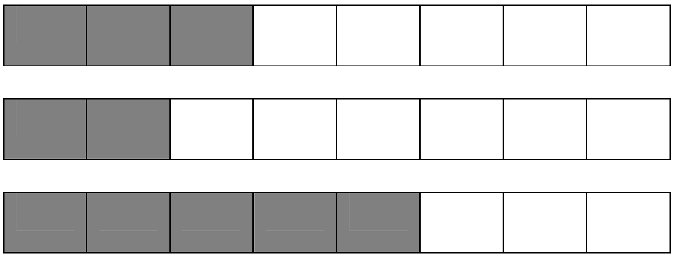
S: The student wrote 1/3

T: Is that correct?

Ss: Yes Sir

T: Introduced the days lesson by saying “We will be comparing fractions”

T: The teacher drew three fraction blocks of equal dimensions, divided into different fractions.



Naomi = $\frac{3}{8}$

Jeremy = $\frac{2}{8}$

Frank = $\frac{5}{8}$

T: Who has the biggest portion in the three fraction blocks?

Ss: Frank

T: Who has the smallest portion?

Ss: Jeremy

T: We can therefore conclude that $\frac{3}{8} > \frac{2}{8}$ and $\frac{5}{8} > \frac{3}{8}$.

T: Compare the fractions $\frac{1}{3}$ and. $\frac{2}{5}$

T: I am right to say $\frac{2}{5} > \frac{1}{3}$

Ss: No

T: Why

Ss: The denominators are not the same.

T: How can we make the denominators equal?

S: By first finding the least common multiple (LCM) of 5 and 3 which is 15.

T: We have to find how many times each of the denominators goes through the LCM and then multiply both the numerator and the denominator of each expression by that number.

T: The teacher wrote $\frac{2}{5}\times\frac{3}{3}$ and $\frac{1}{3}\times\frac{5}{5}$, and a student was called to the board to simplify the expressions by multiplying the numerators and the denominators.

S: The student wrote $\frac{6}{15}$ and $\frac{5}{15}$,

T: We can now conclude that $\frac{2}{5}=\frac{6}{15}>\frac{1}{3}=\frac{5}{15}$.

T: "Compare $\frac{2}{3}$ and $\frac{1}{2}$" The teacher went round assisting students.

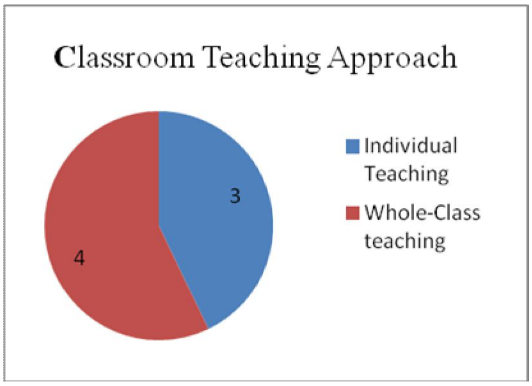


Figure 8. 9: Classroom Teaching Approach

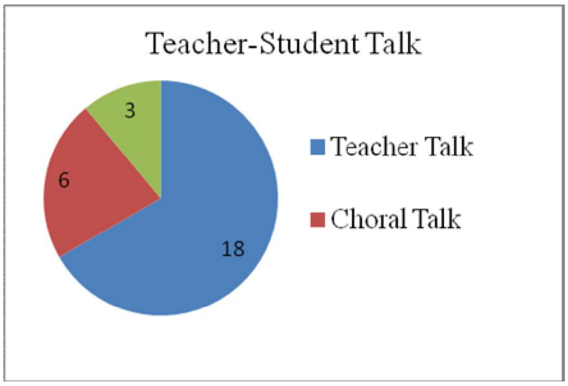


Figure 8. 10: Teacher-Student Talk

It is evident from Table 8.9 that the presentation of the lesson followed a sequence of activities intended to use students' existing knowledge to create new knowledge. Table 8.9 shows that the design and delivery of the lesson was highly influenced by students' ideas, as the teacher built on the students' prior knowledge and misconceptions when presenting the new topic. The teacher employed demonstration, discussion and activity methods when presenting the lesson and students' participation in the teaching-learning process was through a question-answer approach. The teaching process was characterised by both whole-class teaching and individual teaching. For example, of the seven responses from the students, four came as group responses and the other three as individual. Similar to the results from lessons one and two, the proportion of speech by the teacher was higher than that of the students with a ratio of 6:1. However, the proportion of speech by the teacher to that of the students in this lesson was less than that shown in the first two lessons as found by Stigler *et al.* (2000). This result is therefore consistent with the teacher's assertion that he favours a more "communicative student-centred" approach to teaching, as reported in the questionnaire.

Lesson 4: Grouped Frequency Distribution Tables

This topic was a continuation of a previous lesson and it was intended to help students to form grouped frequency distribution tables. The teacher started the lesson by reviewing students' existing knowledge through questioning and written responses based on students' homework. The homework had asked the students to construct simple frequency distribution tables and the teacher pointed out some of the general misconceptions among the students and indicated that some students were writing the tally in the frequency column (see Table 8.10). The teacher corrected the students' misconceptions through demonstration and by using a question and answer approach.

Table 8. 10: Observed Teaching Practices in Lesson 4

Teacher (T): Lets go through the homework questions
T: Some of you were writing the tally in the frequency column
T: What do we put in the tally column?
Students (Ss): Slanted lines indicating the number of times an event occurs.
T: What do we put in the frequency column?
Ss: The actual number representing the number of time an event occurs
T: Frequency tables are used for presenting population data and other data sets in subjects like

social studies and biology

T: How can we present the ages of all the people in Ghana on a frequency distribution table?

Student (S): That will be very tedious and it will take a longer time to do that.

T: Yes, when we have a large data set, we try to group the data and doing so makes the presentation of such data on a frequency distribution table less tedious

T: Grouped frequency distribution table looks like this:

Age	Tally	Frequency
0-10	~~////~~	5
11-20	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ///	23
21-30	~~////~~ ~~////~~ ~~////~~ //	17
31-50	///	3
51-60	//	2
Total		**50**

T: Do you understand?

Ss: Yes

T: Ok, now I want each and every one of you to draw a grouped frequency table of your choice

T: Ok, now lets draw a frequency distribution table for the following set of data which are the marks for students in an exam: 56, 70, 78, 62, 55, 90, 89, 42, 33, 28, 10, 12, 60, 91, 41, 18, 25, 66, 52, 42, 63, 35, 80, 72, 61, 97, 41, 29, 39, 54, 13, 15, 66, 80, 71, 56, 73, 30, 28, 87, 77, 11, 42, 44, 60, 70, 12, 76, 37, 22

T: So what class interval can we use?

Ss: 0-10, 11-20, 21-30.....

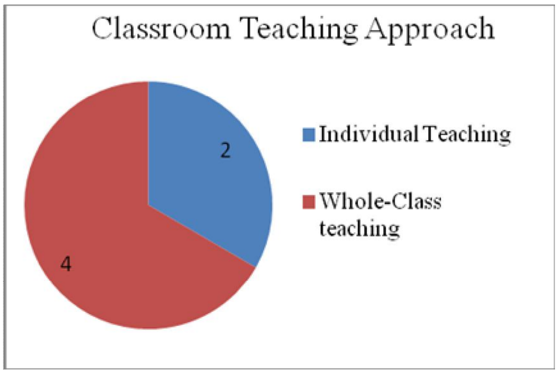
T: Ok, I want you to draw a frequency distribution table for this data.

T: Ok take your time and complete this task and we will solve some more examples during our next lesson

T: Any questions?

S: Sir, in the first example we used age for the different groups, can we use marks in this case?

T: Yes you can use marks or scores.



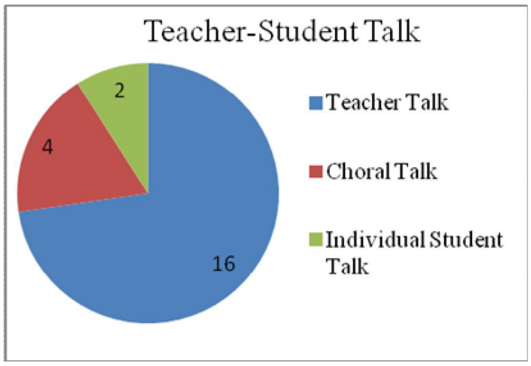


Figure 8. 11: Classroom Teaching Approach　　**Figure 8. 12: Teacher-Student Talk**

From Table 8.10, it is evident that the focus and direction of the lesson was determined by the ideas from the students. The teacher used students' misconceptions and mistakes to develop the new concept: grouped frequency distribution tables. Similar to lesson three, the teacher began the lesson by reviewing the related knowledge of the students through questions and answers. The observed teaching practice followed a sequence of teacher-led activities through the use of discussion and demonstration methods. The teacher incorporated both an individual and a whole-class teaching approach and stimulated both individual students and whole-class participation in the teaching-learning process through questioning. The teacher-centred approach dominated the teaching- learning process, but the use of probing questions stimulated student engagement and participation (Boaler 2009).

According to Willis (2010), the most important activity when learning mathematics is participation and she adds that students' participation without fear of making mistakes stimulates their interest and attitude. The observation data from this lesson supports this, as students' mistakes were not disregarded and the teacher was proactive in using probing questions for students to rethink and correct their mistakes and develop their own ways of solving problems using a variety of methods.

The teacher-student speech ratio in this lesson was 4:1 and this proportion was higher than that observed in lesson three. The resources used in this lesson were the chalkboard and the textbook. Although students had their own copies of the textbook, the books were closed and the only time they were seen using their textbooks was when they were asked to copy down questions as homework. However, it was interesting to note that, despite these inadequate resources, the teacher tried to link each aspect of the lesson to real world situations and used these situations as a method of stimulating students' interest.

Interview Results

This section presents the interview reports, analysis and interpretations of the interviews that this researcher conducted with the mathematics teacher and four students. This section is sub-divided into two further sections; the first part presents the interview report analysis and interpretations of the teacher's interview, and the second part presents the reports and analysis of the student interviews (see Tables 8.11 and 8.12).

Teacher B Interview Report and Analysis

Table 8. 11: Interview Report of Teacher B

Interviewer (I): How do you start your lessons? **Teacher B (TB):** By reviewing students' existing knowledge. I normally use the feedback from homework to review related knowledge and correct students' misconceptions. **I**: So does it mean you give your students homework after each lesson? **TB:** Yes **I**: How do you define teaching well? **TB:** Hmm that is a difficult question. I think it is about presenting the concept for students' understanding. **I:** So under what circumstance will you say you have taught well? **TB**: When I get positive feedback from my students through questioning and the marking of their work **I:** What teaching method(s) do you normally use?

TB: Discussion and activity methods

I: Why do you use these methods?

TB: Oh, they are the most efficient methods

I: Why do you consider these methods to be the most efficient?

TB: You know mathematics is all about the application of mathematical concepts to solve real life problems and it is only through these methods that one can achieve this. You know considering the students' perception of mathematics as a difficult subject and their socio-economic background, it is always appropriate to use an approach which promotes students' interest and active participation.

I: So what are your main priorities when teaching?

TB: To promote students' understanding and develop an interest in the subject through active participation

I: Why do you consider this to be your major priority?

TB: Hmm, because mathematics is a practical subject and getting an understanding of the concept helps in applying mathematics in real world situations.

I: So how do you promote students' participation in your class?

TB: Through questioning and calling students to the board to present their work

I: So what type of questions do you think promote students' participation?

TB: Probing questions

I: Why?

TB: Oh they require the student to think and explore all the possibilities rather than producing factual answers.

I: What's the best way of teaching mathematics?

TB: I do not think there is a single best way of teaching mathematics, but using a combination of different teaching methods and allowing students to develop their own understanding of the concept presented is very important.

I: In your view what is the best way(s) for students to learn mathematics?

TB: Although there is no single best way, from my personal experience, constant practice is the way forward.

Teacher B is a trained teacher and studied mathematics as a minor subject; he has been in the teaching profession for three years. His interview report echoes Felder's (1993) in that individuals vary considerably in how they construct their information to test understanding, knowledge and skills. That is, the responses from this teacher support this assertion, as he reports that he uses a variety of teaching methods to encourage the participation of students because they learn differently and require varied teaching methods.

Willis (2010) states that the *best* way to teach mathematics is to promote students' understanding through active participation. The analysis of the interview results also indicates that the teacher's main priority when teaching mathematics was promoting students' understanding and interest through active participation using a questioning technique. However, mere questioning is not a guarantee of students' active participation and understanding without the additional use of probing questions which stimulate critical thinking among students. This technique was evident in both the observation results and the interview results and it supports the ideas of Steele (2005).

Students' Interview Results and Analysis

Four students, two each from JHS1 and JHS2, were interviewed in this school and the interview reports and analysis are presented in this section (see Table 8.12). Similar to the analysis of the interview results in school A, the interview results in this school are also categorised under four sub-headings: reasons why students learn mathematics, students' participation, students' views regarding what it takes to be successful when learning mathematics and students' preferred ways of learning.

Table 8. 12: Students' Interview Report- School B

Interview Questions/Themes	Descriptions and examples from interview data
How often do you learn mathematics and why?	Core subject – it is a compulsory subject Occupational aspirations- relevant to what the kind of job they want to do in future e.g. accountant Selection- they need to pass their maths examination to gain admission to Senior High School (SHS) Practice – So that they can understand Confidence – Learning helps improve their confidence
If you know the answer to a question will you volunteer to answer it?	Yes – but when they are confident the answer is correct Yes – but when they are called by the teacher Sometimes – when they want to test their understanding No- Because they are not good at mathematics and think their answers may wrong. No- Because their colleagues will laugh at them
What happens if you give a wrong answer?	Correction – the teacher will correct them Mocked - their colleagues will laugh at them
How do you feel when you give a wrong answer?	Shy – as their colleagues may mock them Unhappy- it brings their confidence level down Ashamed- it will look like they have not been paying attention in class Silent – they prefer to be silent
What does it take to be successful when learning mathematics?	Practicing- following the teacher's methods Attention – paying attention in class and following the teacher's instruction Listen - listening to the teacher and following his methods Working with colleagues from other schools – to learn different ways of solving problems
Why do you prefer to learn alone?	Confident- feels confident working alone Familiarity - have been learning alone since primary school
Why do you prefer to learn in groups or with colleagues?	Solve more questions- they are able to solve more questions as a group Correction – they can be corrected by their colleagues Confidence - they are not confident of their ability and working with colleagues boosts their confidence level Variety of ideas - can learn from each other and gain new ideas

Why Students' Learn Mathematics

The individual interviewees responses regarding why they learn mathematics are presented in figure 8.13.

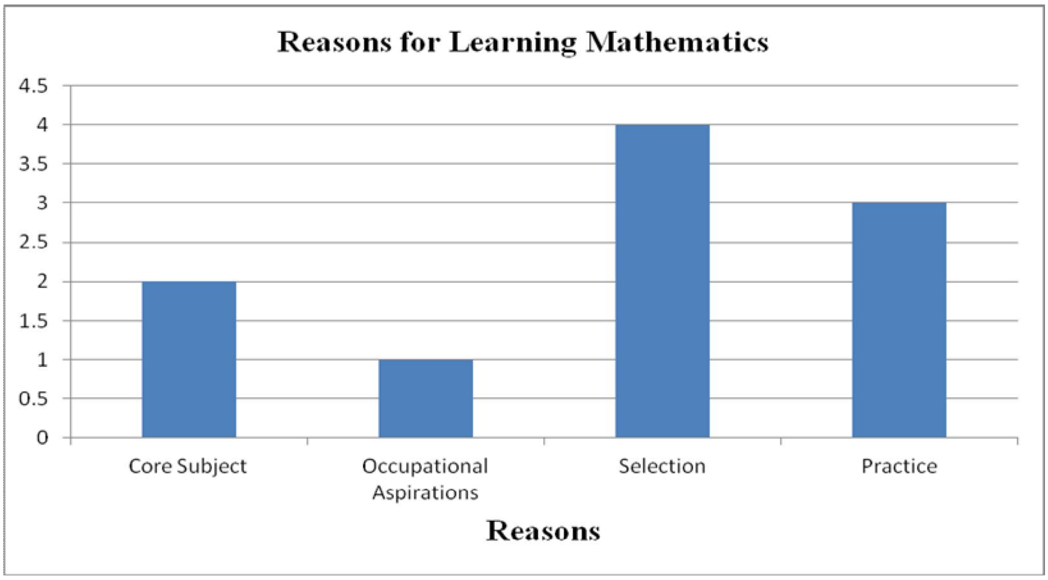


Figure 8. 13: Students' Views about why the Learn Mathematics

Figure 8.13 displays evidence that students learn differently and the most common reason why students learn is to gain admission to Senior High School; all four interviewees indicate that they learn mathematics for this goal. In addition, three of the four interviewees agree that they learn mathematics because they believe that practicing is the best way to learn and two interviewees report that they learn because it is a core subject and they have no choice. One student reveals that he learns mathematics because he wants to be an accountant. The results show that, in addition to mathematics being a core subject, there are several other reasons why students learn mathematics.

Students' Participation in Mathematics Lessons

Figure 8.14 presents a summary of the interviewees' responses regarding their participation in mathematics lessons.

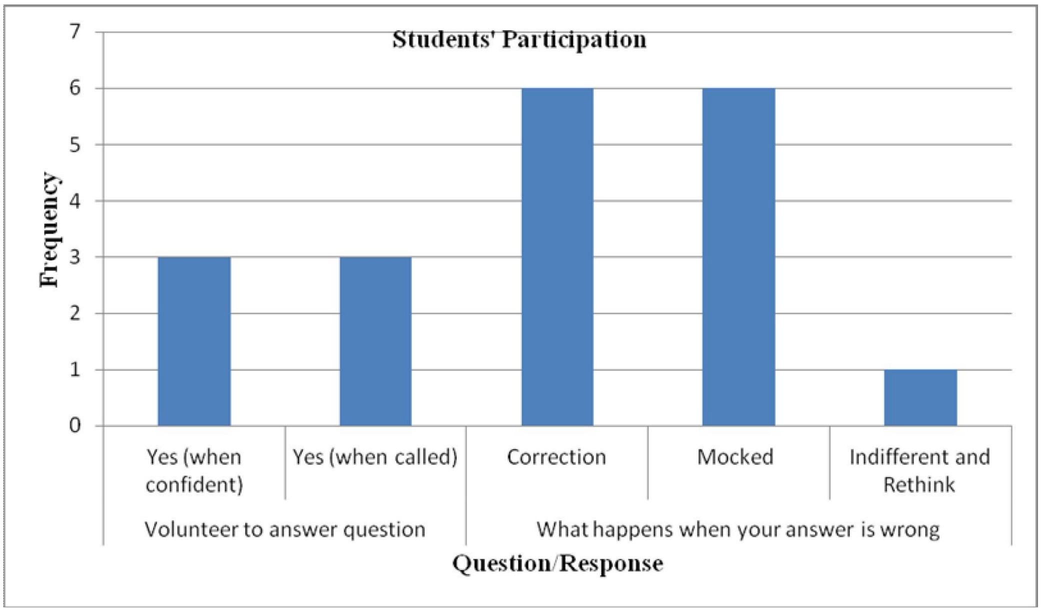


Figure 8. 14: Students' Willingness to Participate

It is evident from Figure 8.14 that all six interviewees expressed their willingness and enthusiasm to volunteer to answer a question if they know the answer. It was interesting to note, however, that when the interviewees were asked if they were willing to answer questions at all times, one of them indicated yes and two indicated sometimes and the other two indicated no (see table 8.12). The works of Boaler (2009) and Willis (2010) have established that students learn well when they make mistakes and their misconceptions are rectified through independent learning whereby individual students take control of their own learning.

The situation in this school is different from the findings of Boaler and Willis, as the results show that providing wrong answers is something that all the interviewees try to avoid. For example, although all four interviewees reveal that the teacher always corrects them when they give wrong answers, they could not hide their displeasure at providing a wrong answer. All four interviewees fear they will be mocked when they give a wrong answer and this makes them uncomfortable and affects their participation in the teaching-learning process. This result implies that a classroom learning environment which is not free from fear and intimidation will have a negative impact on students' participation.

What it Takes to be Successful in Mathematics

Individual student's views regarding what it takes to be successful when learning mathematics were elicited and categorised into three areas. The number of times that each view was mentioned is presented in Figure 8.15 below.

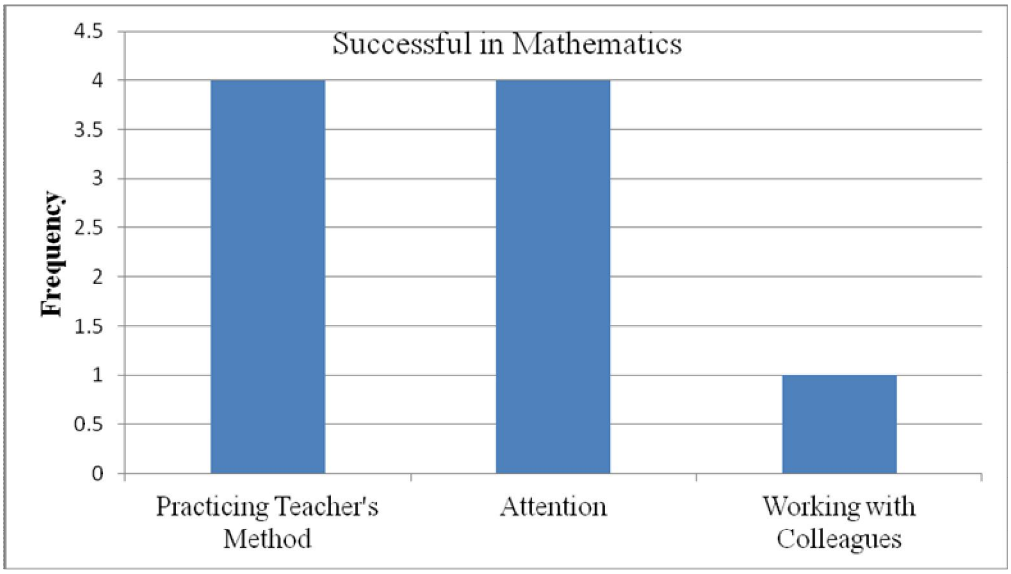


Figure 8. 15: What it takes to be Successful in Mathematics

According to Hodson (1993), the best way to learn mathematics is through the personal and physical involvement of the individual learner in the teaching-learning process. He adds that when students are given the opportunity to play an active role in the teaching-learning process. it promotes independent learning which helps students to be responsible for their own learning experiences. However, from Figure 8.15 it is evident that all four interviewees believe that practicing the teacher’s methods and paying attention in class is necessary to be successful when learning mathematics. On the other hand, one of the interviewees reports that working with colleagues and sharing ideas is necessary. The analysis of the interview reports therefore suggests that the teacher plays an important role in shaping students’ learning experiences and that following the teacher’s instructions and procedures will automatically lead to achieving a correct answer.

Students’ Preferred Ways of Learning

Students’ preferred ways of learning from this school is presented in Figure 8.16

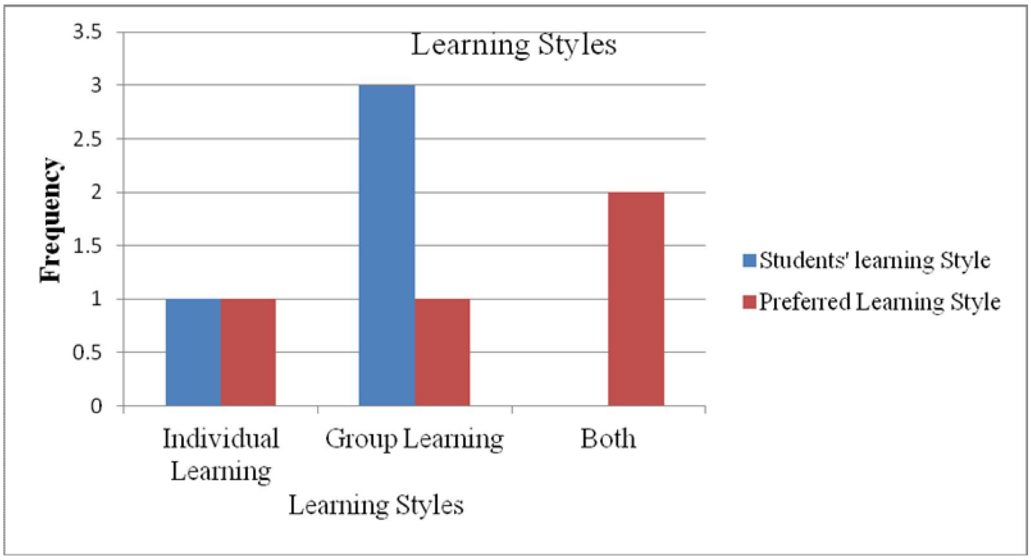


Figure 8.16: Students’ Preferred ways of Learning

Figure 8.16 confirms individual students learn differently and this supports Felder (1993) and Baker’s (2008) assertion that individuals do not learn in the same way. Three of the interviewees report that they prefer to learn in groups and one indicates he prefers learning alone. The three interviewees who would rather learn in groups or with colleagues reveal that learning with their colleagues helps them to access new ideas and find different ways to solve problems. On the other hand, the interviewee who reports that he prefers to learn alone suggests that learning alone makes him feel more confident. Nevertheless, it is also interesting to note that, despite three out of the four interviewees indicating that they learn in groups, only one opines that he prefers to learn in groups, with two indicating they like both learning styles.

Synthesis of Information

The quantitative data from this school establishes that the mathematics teacher has a positive perception and employs different methods in his teaching. In addition, the teacher questionnaire data shows that the teacher directs the students' learning experiences. However, the results also reveal that the teacher sometimes encourages students' participation through questioning and presentation of work on the board. The quantitative data from the students' questionnaire were also consistent with the teacher's perception of his teaching practices. For example, the majority of the students agree that their teacher tries to prevent them from making mistakes by explaining things carefully and their teacher normally tells them which questions to attempt.

The classroom observation results show that students' participation in teaching-learning is controlled by the teacher and this is consistent with the results from the quantitative data. Similarly, the results from the three data sets show that the teaching-learning activities are characterised by a teacher-centred approach; however, students' engagement and participation in the teaching-learning process is also encouraged. The proportion of teaching that is teacher-centred is, however, greater than the proportion of teaching that is student-centred, as shown by the results that address the teacher's perception of his teaching and students' perception of their teacher's teaching.

This implies that, as much as teachers acknowledge the guidelines of the national curriculum and its accompanied teaching and learning practices, the importance of the teacher's active participation in the teaching-learning process to trigger the individual student's learning cannot be underestimated.

Students, on the other hand, still consider their teacher to be an active participant in the teaching-learning process rather than a facilitator; this is evident from the results from both the quantitative and qualitative data.

8.4 Case Study School C

Background School Information

Case study school C is a single sex (female) institution located in a semi-urban community of the metropolis. The school was established in 1875 during the colonial era and is one of the oldest schools in the area. Student enrolment during the 2009/2010 school year was 101, of which 25 of this number were in JHS1, 31 in JHS 2 and 45 in JHS 3. There were 10 teachers in this school at the time of the research, five males and five females; all ten teachers were trained teachers. The school has one mathematics teacher for the three streams and the teacher holds a bachelor of education degree and studied mathematics as a minor subject during his undergraduate studies. This teacher has nine years teaching experience and has been teaching mathematics for the past two years.

Results from Teacher's Questionnaire

The results from the teacher's questionnaire establish that the teacher's main priority when teaching mathematics is to motivate students to develop an interest and positive attitude towards mathematics. According to this teacher, the reason he prioritises this aspect is because the development of such a positive attitude towards mathematics helps students to develop self confidence, which is necessary to develop a conceptual understanding. The teacher also indicates that he uses a variety of teaching methods during his lessons.

He further states that he uses the activity and demonstration methods and sometimes uses lectures, group work and the discovery method to meet the individual needs of his students. The reasons given by the teacher for his choice of a particular teaching method are to encourage student to develop an understanding and, since individual students learn differently, he combines a variety of methods to cater for individual students' needs. This suggests that the teacher has a clear understanding of the fact that individual students are unique and learn differently and therefore require different teaching approaches to help them develop new knowledge and grow their innate capabilities.

The results also establish that similar to the results from the first two schools and the total sample, this teacher starts his lesson by reviewing his students' existing knowledge through questioning and uses a variety of methods to solve a particular problem. This therefore suggests that the teacher understands that learners use their existing knowledge and experiences to develop new knowledge or learn new things. The results also show that the teacher's teaching is dominated by a teacher-centred teaching approach, as he indicates that he does not encourage his students to develop their own methods to solve problems, but prefers them to follow the method and procedures he has given them. The teacher also explains things carefully to prevent his students from making mistakes and normally tells his students which questions to answer.

The teacher also explains that providing or receiving correct answers is paramount and he therefore encourages students not to make mistakes. These skills of teaching are recognised to limit students' extension of knowledge and do not stimulate independent work to encourage students to take full responsibility for their own learning (Willis 2010). In general, similar to the results from the total sample of teachers and the first two schools, the teacher's role in the teaching-learning process in this school goes beyond a facilitator, as outlined in the national curriculum.

Results from Students' Questionnaire

The students' questionnaire was analysed under the following headings: students' perceptions of their learning experiences and students' perceptions of their teachers. The analysis and interpretations of the findings from the 30 students who completed the survey instrument are presented in the following sub-sections.

Students' Perceptions of their Learning Experiences

The 30 students who completed the questionnaire were asked to rank their perceptions of 10 items describing their learning experiences. The first five items represent active learning strategies and the last five passive learning strategies (see Table 8.13).

Table 8.13: Students' Perceptions of their Learning Experiences (School C)

Strategy	Statement	All Schools (n=358)		School C (n=30)	
		Percent	Type	Percent	Type
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with my colleagues	90	Agree	77	Agree
	I compare different methods used to solve questions	87	Agree	90	Agree
	I ask the teacher questions when I do not understand	87	Agree	80	Agree
	I look for different ways to solve problem	75	Agree	80	Agree
	I make up my own questions and methods	61	*	53	*
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	99	Agree	100	Agree
	I copy down the method from the board or textbook	92	Agree	100	Agree
	I attempt easy problems first to increase my confidence	91	Agree	97	Agree
	I only attempt questions I am told to do	78	Agree	60	*
	I work on my own	75	Agree	80	Agree

The results from this school are to some extent consistent with the results from the total sample, as in both cases the majority of the respondents indicate that they listen while the teacher explains. In addition, all the participants in this school agree that they copy down the method from the board or textbook and this is consistent with the results from the total sample. This implies that, although most of the respondents experience mathematics in a passive way, students are sometimes active participants in the teaching-learning process. As is evident from Table 8.13 most of the students show a positive perceptional disposition towards passive learning strategies; however, statistically there was no significant difference (*Mann-Whitney U Test, P=0.06).* In summary, the results suggest that students' experiences of learning mathematics are complex, as they embrace both passive and active learning strategies. Although the consensus agreement scores for passive learning experiences are proportionately higher than those for active learning strategies, they are not statistically significant.

Students' Perceptions of Their Teachers' Teaching

Similar to the results presented for the first two schools, the 30 students in this school were asked to rate their perception of 10 items relating to their teacher's teaching practices (see Table 8.14).

Table 8. 14: Students' Perceptions of their Teachers' Teaching (School C)

Climate	Statement	All Schools (n=358)		School C (n=30)	
		Percent	Type	Percent	Type
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90	Agree	80	Agree
	The teacher asks us to compare different methods for solving questions	87	Agree	90	Agree
	The teacher encourages us to make and discuss mistakes	84	Agree	83	Agree
	The teacher asks us to work in pairs or small groups	77	Agree	67	*
	The teacher encourages us to invent and use our own methods	54	*	50	*
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97	Agree	93	Agree
	The teacher asks us to work through practice exercises	94	Agree	93	Agree
	The teacher shows us which method to use and then asks us to use it.	92	Agree	73	Agree
	The teacher tells us which questions to attempt	92	Agree	97	Agree
	The teacher expects us to follow the textbook closely	74	Agree	77	Agree

Similar to the results from the total sample, the students in this school report that their teachers are more likely to use a teacher-centred approach to teaching rather than a student-centred approach and this was statistically significant (*Mann-Whitney U Test, P=0.007*). It is evident from Table 8.14 that the percentage score of teacher-centred approaches to teaching are higher than student-centred approaches. The data from the total sample and the sample from this school suggest that explaining things carefully to prevent students from making mistakes was the most common teacher-centred method in both cases.

In summary, the students' perceptions of their teacher's teaching were consistent with their teacher's perceptions of his own teaching. For example, similar to the findings from the teachers' questionnaire, the majority (93%) of the respondents agree that their teacher prevents them from making mistakes by explaining things carefully to them. The result implies that students learn through following their teacher’s instructions and the recognised benefit of this approach to learning is that students are able to learn the mathematical concepts they cannot study alone, as identified by Mathews (1997). However, over reliance on the teacher’s instructions and approach does not promote self confidence among students and does not encourage students to take responsibility for their own learning (Boaler 1998).

Classroom Observation

I observed three lessons in this school and the analysis of the results from the individual lessons are presented in this section.

Description of the Lessons Observed

In this school, classes JHS1, JHS2 and JHS3 were observed during the following lessons: order of operations (JHS 1), construction of angles (JHs 2) and interior and exterior angles (JHS 3). The JHS 1 class comprised 25 students and JHS2 and JHS3 classes totalled 24 students each.

Lesson 5: Order of Operations – JHS 1

This lesson was a continuation of a previous lesson and the teacher started the lesson by giving the students a series of questions to answer; these questions were related to knowledge learned in their previous lesson. The teacher called students to the board to solve questions and their misconceptions and mistakes were corrected by their colleagues and the teacher. The review of the related knowledge lasted for 15 minutes, after which the teacher introduced the lesson for the day (see Table 8.15).

Table 8. 15: Observed Teaching Practices in Lesson 5

Teacher (T): Ok let's go through the homework questions.

T: The teacher wrote the first question on the board (solve and simplify the expression $\frac{12}{5} \div (\frac{3}{4} + \frac{1}{8})$

T: I want one of you to come to the board and solve this question. Ok 'Sylvia' can you come to the board?

S (Student): Sylvia wrote: $\frac{12}{5} \div \frac{7}{8} = \frac{12}{5} x \frac{8}{7} = \frac{76}{35}$.

T: Is she is right?

Students (Ss): No Sir

T: Ok what is wrong?

Ss: The simplification was not properly done

T: Ok 'Joyce' can you come to the board and solve the question?

S: $\frac{12}{5} \div (\frac{3}{4} + \frac{1}{8}) = \frac{12}{5} \div \frac{(6+1)}{8}$; $\frac{12}{5} \div \frac{7}{8} = \frac{12}{5} x \frac{8}{7} = \frac{96}{35}$

T: Is she right?

Ss: Yes sir

T: Sylvia do you now know where you went wrong?

S: Yes Sir

T: Ok now we will be looking at more complex problems.

T: Ok close your books and look on the board.

T: Now we will be using the principle of BODMAS (Brackets Order Division Multiplication Addition and Subtraction) to solve problems.

T: The teacher wrote, simplify the expression $\dfrac{2\frac{1}{5} + 3\frac{1}{3}}{\frac{2}{5}}$

T: What is the first thing to be done?

Ss: We have to change all mixed fractions to improper fractions.

T: Ok so we can rewrite this expression as $\dfrac{2\frac{1}{5} + 3\frac{1}{3}}{\frac{2}{5}} = \dfrac{\frac{11}{5} + \frac{10}{3}}{\frac{2}{5}} = \frac{33+50}{15} \div \frac{2}{5} = \frac{83}{16} \div \frac{2}{5}$

T: Do you understand?

Ss: Yes

T: Can we still simplify this further?

Ss: Yes Sir

T: The teacher wrote $\frac{83}{15} \div \frac{2}{5} = \frac{83}{15} x \frac{5}{2} = \frac{83}{3} x \frac{1}{2}$

T: Is this correct

Ss: Yes Sir

T: So we can simplify this further to get $\frac{83}{6}$

T: Ok we will continue with this after lunch.

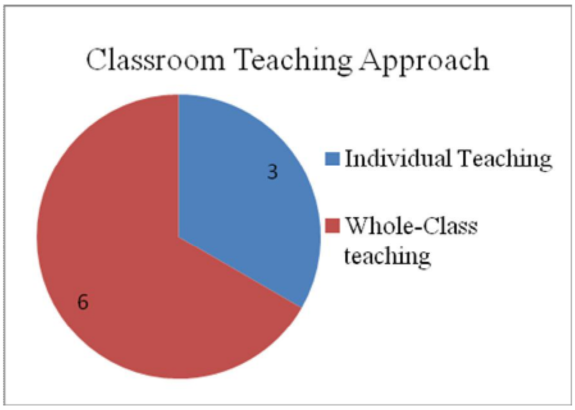


Figure 8. 17: Classroom Teaching Approach

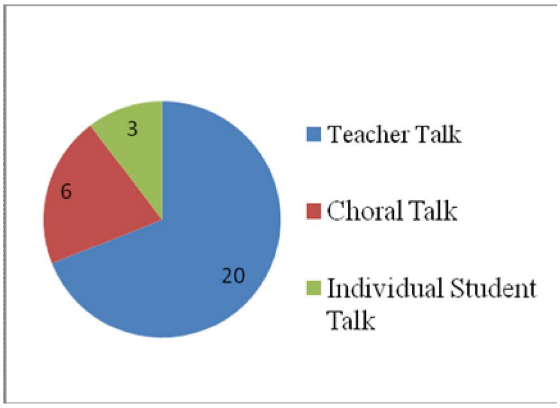


Figure 8. 18: Teacher-Student Talk

From Table 8.15, it is evident that the instructional strategies used follow a sequence of question-answer. The presentation of the lesson is characterised by a teacher-centred approach to teaching with teacher-led activities. Students' engagement in the teaching-learning process is encouraged by the teacher, who calls students to the board to present their work and their mistakes and misconceptions are corrected. Steele (2005) argues that the best way to learn mathematics is through the personal and physical involvement of the individual learner in the teaching-learning process and this approach opens up possibilities for individual students to think and be prepared, as no one knows when he/she will be called to the board.

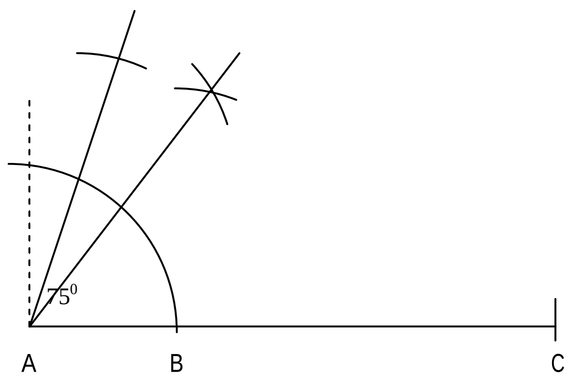
Figure 8.18 shows that the teacher's teaching approach is characterised by whole-class teaching, as the ratio of whole-class teaching and individual teaching was 2:1. According to Ball and Bass

(2000), whole-class discussions and teaching encourage and extend students' mathematical understanding and self confidence. Figure 8.17 also shows that, despite a teaching-learning approach characterised by teacher-centred teaching practices, the teacher encourages students' participation and engagement in the teaching-learning process and this is evident in the proportion of teacher-student speech, which is 6.7:1. In general the teacher encourages students' participation in the teaching learning process; however, similar to the findings from the teacher's and students' questionnaire, the proportion of teacher-centred teaching was higher than student-centred and this is evident in the observed teaching practices and the proportion of teacher-student talk.

Lesson 6: Construction of Angles – JHS 2

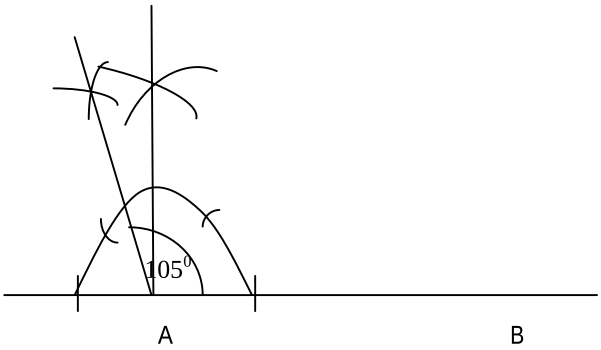
This lesson was a continuation of a previous lesson during which the students were taught how to construct angles 30^0, 45^0, 60^0 and 90^0. The aim of this lesson was to help students to construct angles 75^0 and 105^0 using their related knowledge from the previous lesson. The teacher started the lesson by reviewing the students' existing knowledge from their previous lesson and called two students to the board to construct angles of 45^0 and 60^0; the others were asked to construct these angles in their books. The teacher drew the students' attention to the fact that the use of double lines in the construction of angles is not allowed and they will be penalised if they use this technique in their final examinations (see Table 8.16).

Table 8. 16: Observed Teaching Practices in Lesson 6

Teacher (T): Which angles did we look at yesterday?
Students (Ss): angles 30^0, 45^0, 60^0 and 90^0
T: Ok that is good. So what did we say about the construction of angle 30^0?
Ss: You construct an angle of 60^0 and bisect it.
T: That is good.
T: But you should note that the use of double lines in the construction of angles is not allowed and you will be penalised if you do so in your final examinations.
T: We now want to look at how to construct angles 70^0 and 105^0
T: How can we construct an angle of 75^0 ?
Student (S): 75^0 is the same as 60^0+15^0 (which is a quarter of 60^0 or half of the angle 30^0).
T: Do we all agree?
Ss: Yes Sir?
T: So how do we construct angle 105^0 ?
S: We first construct 90^0 and add 15^0.
T: Ok, now close your books and look at the board.
T: We now want to construct an angle of 75^0 so we will construct 60^0 first and then construct a 15^0 angle and add that.

T: Do you understand?
Ss: Yes sir.
T: Ok, now open your books and construct the angle of 75^0 (teacher went round assisting students)
T: Ok now let's construct an angle of 105^0. We have to construct 90^0 first

T: Take your books and construct an angle of 90^0 (teacher went round assisting students)

T: Ok now all of you have constructed an angle of 90^0. Now put your mathematics instruments down and look on the board (the teacher showed students how to construct the extra 15^0).



T: Ok now open your books and continue following the steps we have just used on the board (the teacher went round assisting students)

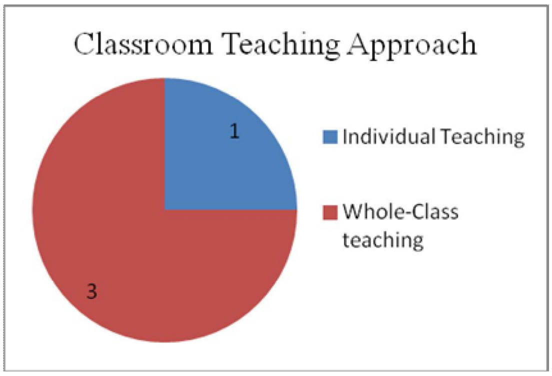


Figure 8. 19: Classroom Teaching Approach

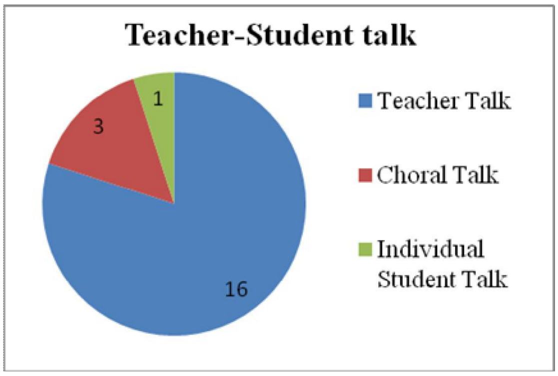


Figure 8. 20: Teacher-Student Talk

In this particular lesson, the teacher's actions centre on helping students to develop an understanding of the construction of angles through their active participation. The sequence and presentation of the lesson consist of demonstration and activity methods and all the activities are controlled by the teacher. As shown in Table 8.16, throughout the lessons students' actions and engagement in the teaching-learning process can be described as procedural, as they are encouraged to adhere to their teacher's approach, which the students accept without question. Although the teacher encourages students' participation through asking questions, most are factual questions which do not give the students the opportunity to think mathematically and develop a conceptual understanding (Boaler 2009). The results also establish that the observed teaching is characterised by whole-class teaching with no form of group work among students. In addition, the results reveal that the ratio of teacher-student speech is 16:1, which suggests that the teaching process is dominated by the teacher's actions.

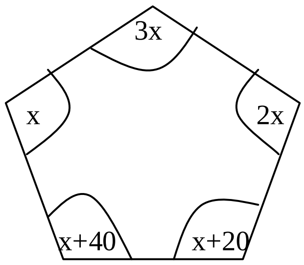
Lesson 7: Interior and Exterior Angles – JHS 3

The teacher started this lesson by reviewing the students' existing knowledge through asking questions. When reviewing this knowledge, the teacher asked students if they could recall the formulae for finding the interior and exterior angles of a regular polygon which they learned in their previous lesson. The teacher then explained to the students that they will be continuing with what they have learned and will use the interior and exterior angles of regular polygon formulae to solve some questions. The teacher reiterated the need for students to remember these formulae at all times as they prepare for their final examinations.

Table 8. 17: Observed Teaching Practices in Lesson 7

T: What is the formula for finding the interior angles of a regular polygon?
S: (n-2)180 (by referring to her notes)
T: Is that correct?
Ss: Yes Sir
T: Ok, what is the formula for finding the exterior angles of a regular polygon?
Ss: $\frac{360}{n}$
T: Where n is?
Ss: The number of sides of the regular polygon

T: Ok then let's find the value of X in this figure



T: So which of the two formulae do we use?

Ss: (n-2)180

T: Why?

S: Because we are finding the interior angle of a polygon.

T So we can write 180 (5-2) = 180(3) = 540, since we know n to be equal to 5.

T: So we sum the interior angles and equate it to 540. (The teacher then wrote $x+3x+2x+x+40+x+20=540^0$)

T: What do we do next?

Ss: We simplify

T: Ok, so we can write $8x=540-60$, $8x=480$. Therefore $x=\dfrac{480}{8}=60^0$

T: The value of angle X is 60^0

T: Do you understand?

Ss: Yes sir

T: Ok find the sum of the interior angle of a regular polygon with seven sides

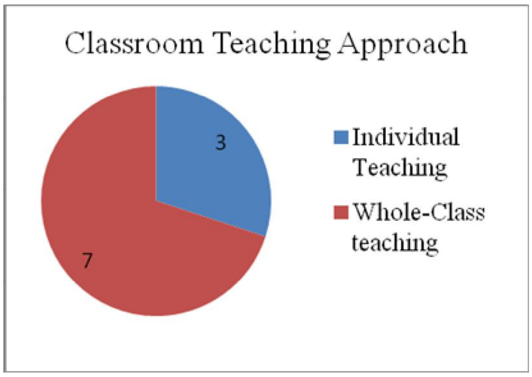
T: Do that in your books I will go round to check

T: Ok what did you get "Tina"
S: 900

T: Did we have the same answer?

Ss: Yes Sir?

T: Ok, in our next lesson we will look at how to find the sum of the exterior angles of a polygon.



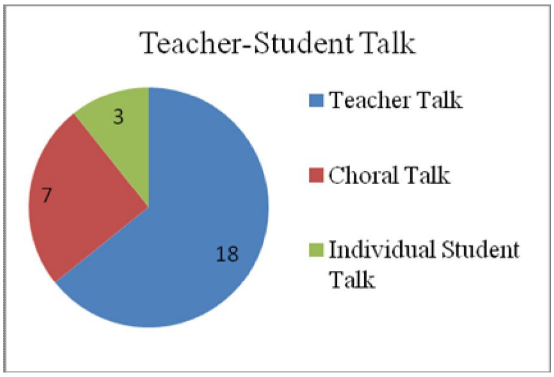


Figure 8. 21: Classroom Teaching Approach **Figure 8. 22: Teacher-Student Talk**

It is evident from Figure 8.22 that, similar to the other two lessons observed in this school, this lesson also follows the same teacher-led approach through the use of demonstration and activity methods of teaching. Teacher-student and student-student interaction in this lesson is very minimal and the students only passively participate by accepting and using the teacher's approach without question. The students follow the teachers' procedures strictly without looking for any other form or way to solve the problem. The cumulative effect of this approach to learning leads to a procedural approach to solving problems. This does not encourage students to think critically or make informed judgements (Mapolelo 2009).

In general, the results show that the teacher's approach was characterised by a question-answer scenario and the proportion of speech by the teacher was significantly higher than that of the students. Also, as observed in the other two lessons in this school, group work or small group discussions among students are not part of this lesson, although both the teacher and the students indicate in the questionnaire that students are encouraged to work in groups.

Interview Results

This section presents the teacher's and students' interview reports, analysis and interpretations; it is sub-divided into two sections. The first part presents an analysis of the teacher's interview reports and interpretations and the second part presents the analysis and reports of the interviews I held with the six students (two each from JHS1, JHS2 and JHS 3).

Teacher's Interview Report and Analysis

Table 8. 18: Interview Report of Teacher C

Interviewer (I): How do you normally start your lessons? **Teacher C (TC):** Oh the normal procedure, reviewing students' related knowledge and building on what they know already. **I**: How will you define teaching well? **TC:** Teaching well involves the teacher's ability to improve students' understanding. **I**: Ok, so under what circumstances will you be assured you have taught well? **TC**: When students are able to provide correct answers to questions or tasks I set for them. **I**: Ok so what teaching methods do you normally use? **TC:** Activity and demonstration methods. **I**: So why do you use these methods? **TC:** These are the methods that teachers are encouraged to use in the national curriculum. **I**: So do you think the use of other methods will help your students? **TC:** Yes, for example discovery and problem solving methods are good, but I do not normally use them. **I**: Why? **TC**: They are time consuming and we do not have enough time to finish the whole syllabus. **I**: Ok so what are your main priorities when teaching? **TC**: Oh to motivate students to develop an interest and positive attitude toward mathematics. **I**: Why do you consider this to be your main priority? **TC:** Oh you know there is this general perception that mathematics is difficult and I think motivating and helping your students to develop a positive attitude toward the subject helps. **I**: So how do you achieve this?

TC: Through the use of variety of teaching methods, for example the activity and demonstration methods help students to understand the concept presented. You know, the use of a variety of methods helps individual students to play an active role in the teaching-learning process, as their individual needs can be addressed.

I: So how do you promote students' participation?

TC: Through questioning and assisting students to develop a procedural understanding to solve a particular problem. Also, making the lesson practical and using group work among students helps to promote students' participation.

I: In your view what is the best way of learning mathematics?

TC: I think it depends on the individual, but I see regular practice and group work as the way forward.-

From Table 8.18 shows that teacher C, who has nine years teaching experience and two years experience as a mathematics teacher, acknowledges the importance of students' active participation in the teaching-learning process. He explains that he employs a variety of teaching methods to motivate and stimulate students' participation, interest and understanding of the mathematical concepts he presents to them. Also from Table 8.18, it is clear that students' participation in the teaching-learning of mathematics is centred on a question and answer strategy. According to Boaler (2009), questioning is one of the most effective ways to encourage students' participation in the teaching-learning process, as it stimulates critical thinking among students.

However, solely answering questions does not promote independent learning and not all questions stimulate critical thinking among students. For example, in all the three lessons taught by teacher C he used questioning to encourage students' participation; however, most of the questions asked were factual. In most cases, students were either asked to recite a formula or to respond in favour of the teacher's approach without query and were not given the chance to explore and develop new knowledge (Steele 2005).

Students' Interview Reports and Analysis

This section presents the interview results and analysis with regard to the six students who were interviewed in this school. The interview responses are categorised under four headings: reasons for learning mathematics, students' participation, students' views regarding what it takes to be successful when learning mathematics and students' preferred ways to learn.

Table 8. 19: Students' Interview Responses - School C

Interview Questions/Themes	Descriptions and examples from interview data
How often do you learn mathematics and why?	Difficult – because mathematics is a difficult subject Occupational aspirations- relevant to the kind of job they want to do in future- medical doctor, engineer Weak- they think they are weak in mathematics
If you know the answer to a question will you volunteer to answer it?	Yes – but when they are confident the answer is correct Yes – but when they are called by the teacher Sometimes – when they want to test their understanding No- because they are not good at mathematics and think their answers may be wrong No- because their colleagues will laugh at them
What happens if you give a wrong answer?	Correction – the teacher will correct them Mocked- their colleagues will laugh at them
How do you feel when you give a wrong answer?	Shy – as their colleagues may mock Unhappy- it brings their confidence level down Ashamed- will look like they have not been paying attention in class Silent – they prefer to be silent Indifferent – does not affect them in any way
What does it take to be successful when learning mathematics?	Practice- following teachers' methods Other methods – looking for alternative methods Listening- listening to the teacher and following his methods
Why do you prefer to learn alone?	Confident- feels confident working alone Examination- the final examination does not include group work
Why do you prefer to learn in groups or with colleagues?	Understanding- they understand well when they learn together Correction – they can be corrected by their colleagues Variety of ideas- they can learn from each other and get new ideas

Why Students Learn Mathematics

The individual responses from the six students regarding why they learn mathematics were collated, quantified and categorised into four different themes: core subject, perception, occupational aspirations and confidence.

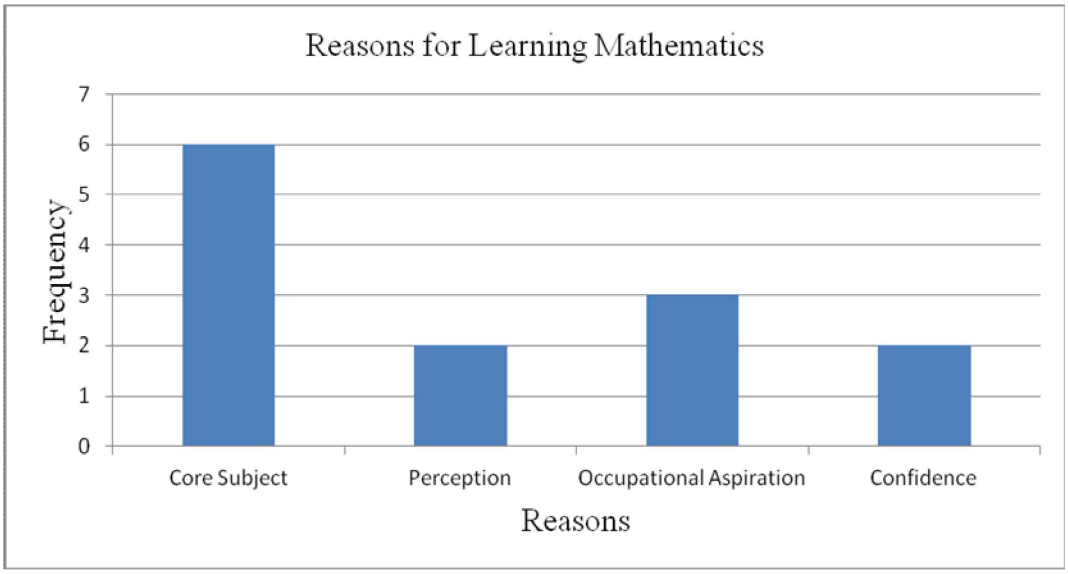


Figure 8. 23: Students' Views about why they Learn Mathematics

All the six interviewees report that they learn mathematics because it is a core subject and two suggest that they learn mathematics because it is a very difficult subject and they must practice every day in order to attain a good grade. In addition, three of the respondents opine that they learn mathematics because of their future occupational aspirations and two of the interviewees reveal that they learn mathematics to become confident. In general, the results show that there are different reasons why individual students learn mathematics, but the common reason is the fact that mathematics is a core subject. Moreover, the interview results show that, apart from being a core subject, a number of the students have clear future occupational aspirations and in order to succeed in these goals they must do well in mathematics (Keith, 2000).

Students’ Participation in Mathematics Lessons

The individual interviewee’s responses regarding their willingness to answer questions in class and what happens when they give a wrong answer were collated and quantified and the results are presented below in Figure 8.24.

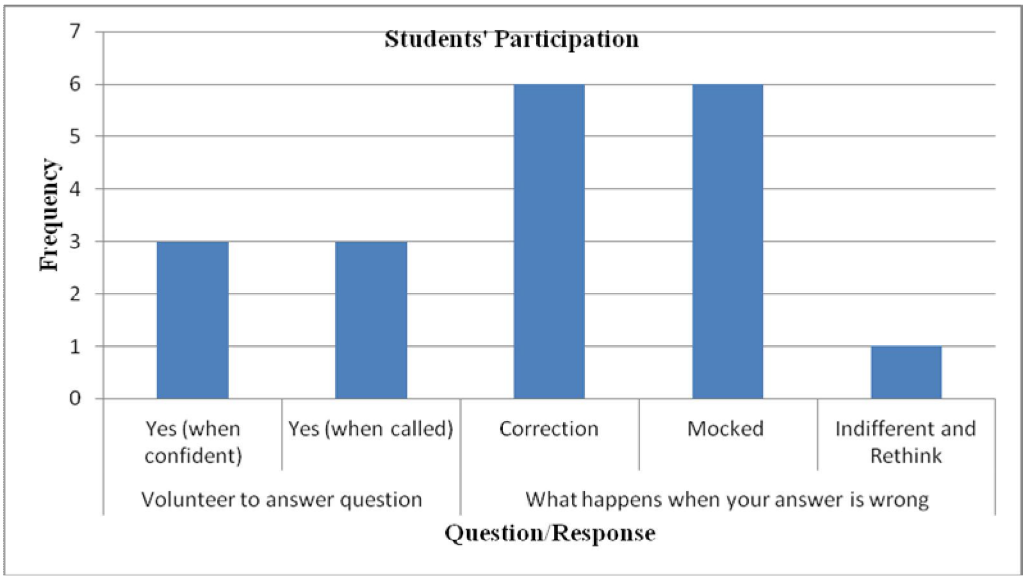


Figure 8. 24: Students' Willingness to Participate

Figure 8.24 shows that all the interviewees are enthusiastic in volunteering to answer a question in class if they know the answer. Students’ willingness to play an active role in the teaching-learning process stimulates their development of new knowledge (Ampadu 2011). The findings, however, challenge this notion, as despite the fact that all the students express their willingness and enthusiasm in playing an active role in the teaching-learning process, they all raise concerns about being mocked when they give an incorrect answer.

The findings therefore suggest that mere willingness to participate in the teaching-learning process does not necessarily stimulate individual students’ learning; however, learners’ willingness, together with the existence of a conducive environment free from fear and intimidation, to a large extent promotes students' participation in the teaching-learning process, as evident in Figure 8.24. For example, four of the interviewees report that they become more confident when they correctly answer a question and state that making mistakes is something they all try as much as possible to avoid. In addition, all the interviewees also reveal that their teacher will normally correct them when they make mistakes. However, it is interesting to note that all the interviewees believe that their colleagues will mock them when they give a wrong answer. Only one of the interviewees says that she feels indifferent when she gives a wrong answer; the other five state that they feel uncomfortable when they give a wrong answer. In general, the interview results suggest that the learning experiences of students are influenced by feedback from their peers and more students will be willing to be actively involved in the teaching-learning process if their answers are acknowledged, even if they are wrong.

What it Takes to be Successful When Learning Mathematics

Al the interviewees were asked to express their views regarding what it takes to be successful in mathematics. The individual responses from the interviewees are therefore categorised into the following themes: practicing teacher's methods, attention, answering and asking questions and looking for different methods of solving problems (see Figure 8.25).

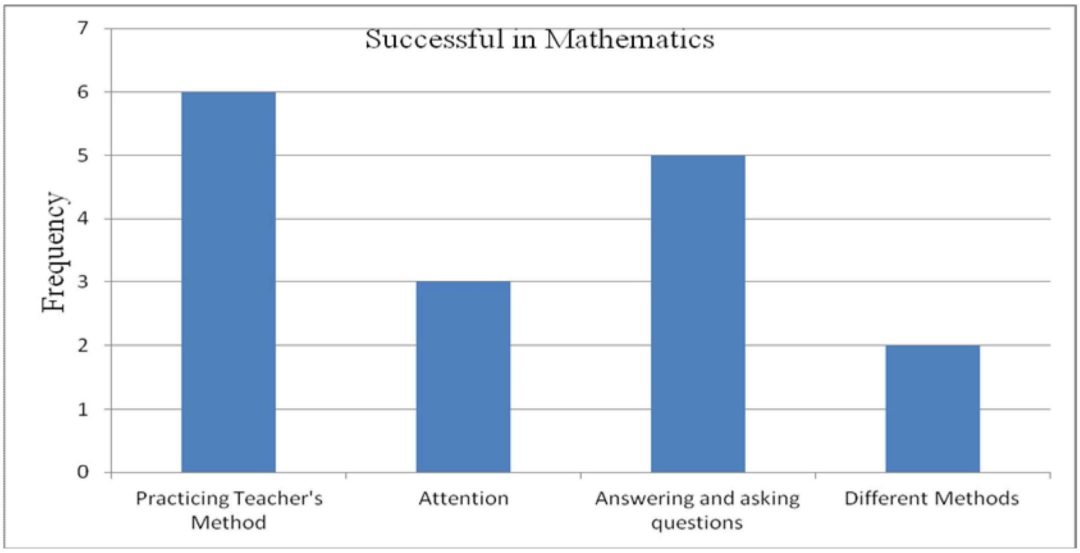


Figure 8. 25: What it takes to be Successful in Mathematics

Figure 8.25 shows that the interviewees have differing views regarding what it takes to be successful in mathematics. However, all the interviewees report that practicing the teacher's methods is the surest way to be successful and three also mention that paying attention can help one to be successful in mathematics. In addition, five of the interviewees indicate that answering and asking questions are a factor of success. Two of the six interviewees also state that looking for different ways to solve problems can help one to be successful when learning mathematics. It is evident from Figure 8.25 that students' experiences of learning mathematics may differ considerably; however, their learning experiences are characterised by a procedural approach to learning and adhering to the teacher's instructions, with less opportunity for creativity and independent learning.

Students' Preferred Ways of Learning

To better understand students' learning experiences, the interviewees were asked to indicate whether they prefer learning alone or in groups. This section therefore presents the results and interpretations of the interviewees' responses (see Figure 8.26).

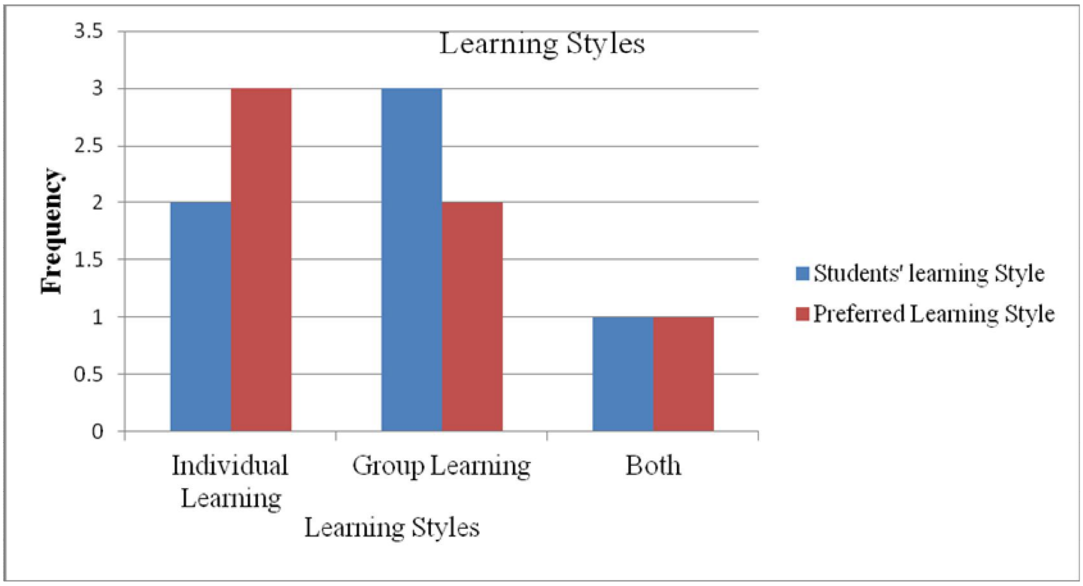


Figure 8. 26: Students' Preferred Learning Styles

Working together stimulates students' understanding and offers the opportunity to learn from each other; it also helps students to be responsible for their own learning (Roj- Lindbergh 2001). In Figure 8.26, two of the interviewees report that they normally learn alone and three indicate that they normally learn in a group. Also, one interviewee reveals that she does learn individually, but also with her colleagues. However, three of the interviewees state that they prefer to learn alone and two agree that they prefer to learn in groups, while one prefers both methods.

It was interesting to note that, although the students recognise the importance of learning in groups, some them think working alone is desirable. For example, all three students who indicate they prefer to learn alone explain that, although learning together helps them to learn new ways to solve problems and they gain new ideas from their colleagues, during their final examination there will not be any form of group work.

Synthesis of Information

The analysis of the quantitative data from the teacher's questionnaire shows that the teacher's perception of his teaching could be described as both teacher-centred and student-centred. The results also show that the teacher promotes students' participation through questions and tries to explain things carefully to his students to prevent them from making mistakes. The analysis of the quantitative data from the students' questionnaire has also established that students' experiences are controlled and directed by the teacher, who tells the students which questions to answer and what methods to use. Students' perceptions of their teacher's experiences are consistent with their teacher's perceptions, as most of the students state that their teacher tries to prevent them from making mistakes and also tells students which questions to attempt.

The analysis of the classroom observation also establishes that students' participation in the teaching-learning process is mostly through a question-answer approach and students' participation is controlled by the teacher. Similarly, the interview data reveals that students' learning experiences comprise answering questions with little or no independent work among students. Furthermore, students are not encouraged to look for different ways to solve problems, although the teacher indicates in the questionnaire that he encourages this.

8.5 Case Study School D

Background School Information

Case study school D is a single sex (girls) school located in an urban community of the metropolis and was established in 1926. Student enrolment during the 2009/2010 academic year was 205, of which 85 were in JHS1, 64 in JHS2 and 56 in JHS3. The school had 12 teachers, six male and six female, and all 12 were trained teachers. There were three mathematics teachers in this school and all hold a bachelor of education degree; two of these teachers studied mathematics as a major course and the other read mathematics as a minor course during their teacher training programme.

Results from Teachers' Questionnaire

The results from the teachers' questionnaire in this school show that all three teachers have a similar perception regarding their teaching methods, priorities for teaching mathematics and how they start their lessons. For example, all three indicate that they often use activity and demonstration methods during their lessons and they all say that they never use the lecture method. One of the teachers states that he uses a combination of demonstration and activity methods to stimulate students' understanding and promote students' active participation. Another teacher also reveals that he uses a combination of these methods because students learn by doing engagement in a lot of activities encourages critical thinking and independent learning among the students.

In addition, the results show that the main priority of all three teachers when teaching mathematics is to motivate students to be interested in and have a positive attitude towards the subject. One of the teachers further opines that learning mathematics is all about having an interest and motivation, which is necessary for independent learning. The results also reveal that all the teachers start their lesson by reviewing their students' existing knowledge and all three teachers agree that they encourage their students to look for different methods to solve problems. Hodson (1993) and Willis (2010) suggest that the best way to learn mathematics is to be actively involved in the teaching-learning process, to explore and look for different methods of solving problems and also see mistakes as part of the learning process.

However, it is interesting to note that, despite all the teachers indicating that they encourage their students to look for alternative methods of solving problems, they all report that they give their students procedures to follow and explain things carefully to their students to help them avoid mistakes. Felder (1993) believes that students learn differently and the use of different teaching methods increasing the individual student's understanding. The results support this statement, as all three teachers indicate that they use a variety of teaching methods to promote students' understanding, as students have different learning styles and bring different behaviour and backgrounds to the classroom. The results also reveal that, as much as students' participation is encouraged through questioning, students' learning experiences are limited to answering the teacher's questions; the teacher normally tells the students what to do and this does not stimulate critical thinking among students (Steele 2005).

Results from Students' Questionnaire

In all, 30 students completed the questionnaire in this school and the results and analysis of the data from the students' questionnaire is presented in the subsequent sections. The students' questionnaires are analysed under two main themes: students' perceptions of their learning experiences (see Table 8.20) and students' perceptions of their teachers' teaching (see Table 8.21).

Table 8. 20: Students Perceptions of their Learning Experiences (School D)

Strategy	Statement	All Schools (n=358)		School D (n=30)	
		Percent	Type	Percent	Type
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with my colleagues	90	Agree	87	Agree
	I compare different methods used to solve questions	87	Agree	83	Agree
	I ask the teacher questions when I do not understand	87	Agree	77	Agree
	I look for different ways to solve problems	75	Agree	67	*
	I make up my own questions and methods	61	*	50	*
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	99	Agree	100	Agree
	I copy down the methods from the board or textbook	92	Agree	90	Agree
	I attempt easy problems first to increase my confidence	91	Agree	93	Agree
	I only attempt questions I am told to do	78	Agree	70	Agree
	I work on my own	75	Agree	63	Agree

According to Dart *et al.* (2000), active learning involves seeking meaning and understanding the material being studied through elaborating and transforming the material; this makes the student responsible for his/her learning. Such opportunities promote conceptual understanding and give students the opportunity to take responsibility for their own learning. Table 8.20 shows that the majority of students in this school experience mathematics in a passive way, as their learning experiences are directed and controlled by the teacher. There are statistically significant (*Mann-Whitney U Test, P=0.001*) differences in how students perceive their learning experiences in terms of active and passive learning strategies.

Table 8. 21: Students Perceptions of their Teachers Teaching (School D)

Climate	Statement	All Schools (n=358)		School C (n=30)	
		Percent	**Type**	**Percent**	**Type**
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90	Agree	77	Agree
	The teacher asks us to compare different methods for solving questions	87	Agree	83	Agree
	The teacher encourages us to make and discuss our mistakes	84	Agree	73	Agree
	The teacher asks us to work in pairs or small groups	77	Agree	77	Agree
	The teacher encourages us to invent and use our own methods	54	*	93	Disagree
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97	Agree	100	Agree
	The teacher asks us to work through practice exercises	94	Agree	87	Agree
	The teacher shows us which method to use and then asks us to use it	92	Agree	97	Agree
	The teacher tells us which questions to attempt	92	Agree	93	Agree
	The teacher expects us to follow the textbook closely	74	Agree	50	*

Table 8.21 shows that students' perception of their teachers teaching are characterised by a teacher-centred approach to teaching. It is noticeable from Table 8.21 that teachers' teaching practices follow a structured process where students are introduced to facts and procedures with little or no extension of students' mathematics knowledge. Most (93%) of the students do not agree that they are encouraged to invent and use their own methods. In addition, students' mistakes and misconceptions are not encouraged and this is consistent with the teacher's results, as all the teachers indicate that they try to explain things carefully to prevent students from making mistakes.

It can be concluded that the teacher plays an important role in the teaching-learning process and students' learning experiences are dependent on the nature of the classroom environment.

According to Alseth *et al*. (2003) the traditional approach to teaching mathematics, in which students are told which method to use and practise solving textbook tasks, is still the normal way of teaching in most mathematics classrooms, and the results from this school confirm their claim.

Classroom Observation

In this school I observed three lessons: types of sets (JHS 1), indices (JHS 2) and factorisation (JHS 3). This section presents a description of the lessons and the teaching and learning strategies observed.

Description of the Lessons Observed

This section gives a brief overview of the individual lessons observed with reference to the content of the lesson and how it was introduced.

Lesson 8: Types of Sets – JHS 1

The topic for this lesson was types of sets and it was aimed at helping students to understand the concept of sets. The teacher started the lesson by asking the students the meaning of a set and the students gave a series of definitions. The teacher then informed the students that they will be looking at the different types of sets used when representing data (see Table 8.22).

Table 8. 22: Observed Teaching Practices in Lesson 8

T: What is a set?
S: A set is a collection of objects
S: A set is a group of objects
S: A set is objects of the same kind
T: Well done you are all right
T: A set is a group of objects of the same kind
T: Write this definition in your books
T: What are examples of such groups of objects?

S: Domestic animals

T: Ok what else

Ss: Counting numbers, even numbers and odd numbers

T: Ok, today we will be looking at the following types of sets: universal set (union set), empty set, equal set, unit set, subset and complement set

T: A universal set is the union or mother set of all sets. For example, we can have the set of female teachers and the set of male teachers and the union set will be the set of all teachers.

T: Do you understand?

Ss: Yes.

T: Ok, now give two different sets and a union set to represent these sets (teacher went round assisting students)

T: So do we all understand what a union set is?

Ss: Yes sir.

T: The symbol for a union set is U

T: Ok, the next set is an empty set and as the name implies it is a set with no element and we sometimes call this set a null set (the teacher wrote Ø as the symbol for an empty set)

T: Now let's look at equal sets

T: Two or more sets are equal when they have the same elements. Example, if A = {days of the week} and B= {Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday}, then the sets A and B are equal.

T: Do you understand?

Ss: Yes sir

T: The next is a unit set. A unit set is a set with only one element. For example if A = {Monday}, then A is a unit set.

T: Ok before we continue, open page five of your textbooks and solve questions 1-6

S: Sir should we do that in our exercise books or notebooks?

T: Exercise books

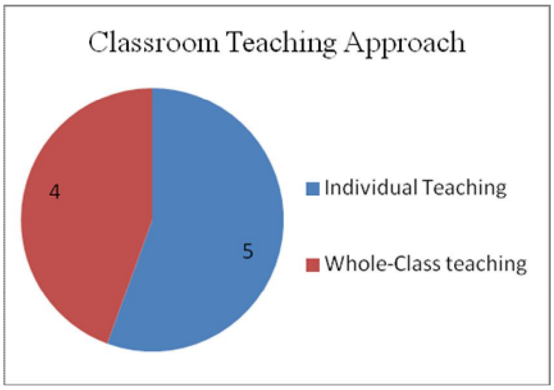


Figure 8. 27: Classroom Teaching Approach

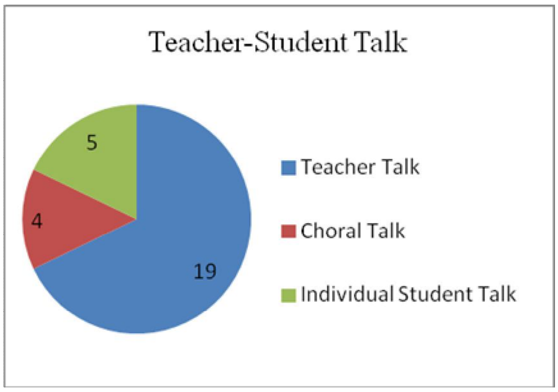


Figure 8. 28: Teacher-Student Talk

Table 8.22 shows that the teaching practice used in this lesson follows a teacher-centred approach in which the teacher directs most of the activities, using demonstration and activity methods to help students to understand the concept of sets and the different types of sets. Students' participation in the teaching-learning process is characterised by responses to the teacher's questions, either by producing an answer to a factual question or agreeing with the teacher's statements. It is evident from Figure 8.27 that the classroom teaching approach is dominated by whole-class teaching and, contrary to the findings from the questionnaire, group work is minimal. The learning process is characterised by individual work and the only time that student's talk to each other is when they compare answers.

Lesson 9: Indices – JHS 2

The topic presented in this lesson was Laws of Indices and the lesson was intended to help students understand the laws of indices and apply them to solving questions. This was a continuation of a previous lesson in which the students had already been introduced to the topic (see Table 8.23).

Table 8. 23: Observed Teaching Practices in Lesson 9

T: We started looking at the laws of indices yesterday and how many laws did we look at?

Ss: Three

T: What are the three basic laws of indices?

Ss: $a^m x a^n = a^{m+n}$; $a^m \div a^n = a^{m-n}$, $a^{(m)n} = a^{mn}$

T: Ok let's simplify $7^2 x 3^4 x 7^{-1} x 2^2 \; x 3^2$.

T: What is the first step in simplifying any expression?

Ss: Group all like terms

T: I am right to say $7^2 x 3^4 x 7^{-1} x 2^2 \; x 3^2 = (7^2 \; x \; 7^{-1}) x (3^4 x 3^2) \; x \; 2^2$?

Ss: Yes sir

T: Ok now using the first and second laws of indices, we can say

$(7^2 \; x \; 7^{-1}) x (3^4 x 3^2) \; x \; 2^2 = 7^{2-1} x 3^{4+2} x 2^2$

Therefore $7^2 x 3^4 x 7^{-1} x 2^2 \; x 3^2 = 7^1 x 3^6 x 2^2$.

T: Do you understand?

Ss: Yes sir

T: Ok let's look at the third law (teacher wrote simplify $2^6 \div 2^3$)

T: Felicia can you come to the board and simplify this?

S: $2^6 \div 2^3 = 2^6 x 2^3$.

T: Is she right?

Ss: No

T: Who can help Felicia? Yes Grace

S: $2^6 \div 2^3 = 2^{6-3} = 2^3$

T: Is she right?

Ss: Yes sir

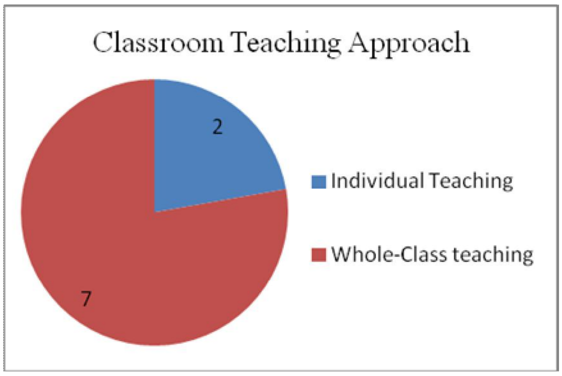
T: Ok simplify the following in your note books (teacher went round assisting students)

$4^4 \div 4^1$ $(2^6 \div 2^3) \; x \; (2^4 \div 2^1)$

$3^6 \div 9^2$

$25^8 \div (2^3 x 8^2)$

T: Ok it is lunch time we will continue during the next period



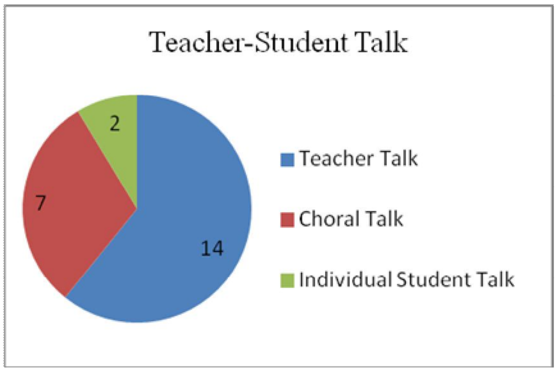


Figure 8. 29: Classroom Teaching Approach **Figure 8. 30: Teacher-Student Talk**

From Table 8.23, it is evident that the teaching approach comprises teacher directed activities through the use of activity, demonstration and lecture methods. Students' participation in the teaching-learning process is through answering the teacher's questions or expressing their agreement with the teacher's method. The whole-class teaching approach dominates the lesson and the proportion of whole-class teaching to individual class teaching is 7:2. Group teaching is not evident in the entire lesson and the only time that students' talk to one another is when some students compare their answers. The teacher's activities dominate the entire lesson and this is evident from Figure 8.30, which establishes that the rate of teacher-student speech is 7:2. In general, the teacher combines activity, demonstration and lecture methods when presenting the concept, but the lecture method is predominant throughout the lesson. Students passively participate in the lesson, as they are not given the opportunity to explore and construct their own knowledge (Steele 2005).

Lesson 10: Factorisation – JHS 3

The topic for this lesson was factorisation and its aim was to help students to develop an understanding of the concept and how to use it when solving problems. The teacher started the lesson by reviewing students' existing knowledge on common factors, and the simplification of algebraic expressions (see Table 8.24).

Table 8. 24: Observed Teaching Practices in Lesson 10

T: What is the common factor in the expression $ab+ac$?
S: a
T: Ok, what number or variable should be multiplied by a to give ab?
Ss: b
T: So I can write $ab+ac=a(b+c)$?
T: Factorisation is the process of finding the common factors of an expression.
T: Do you understand?
Ss: Yes sir.
T: Ok let's factorise the expression $4n+8s$
T: What is the common factor here?
S: 4
T: Is that right?
Ss: Yes sir
S: Sir what about 2?
T: 2 is a common factor of 4 and 8 but we look for the highest common factor which is 4.
T: Do you get that?
Ss: Yes Sir
T: So that means we can factorise 4 out which gives us $4n+8s=4(n+2s)$
T: Is that clear?
Ss: Yes sir
T: Let's factorise $3a^2+2ab-12ac-8bc$
T: Close your books and look on the board. When we have four different expressions like this we have to divide them into two.
T: So let's group the first two expressions and the last two (the teacher wrote (($3a^2+2ab)+(-12ac-8bc)$
T: Are you with me?

Ss: Yes sir

T: So what is the common factor in the first bracket and the second bracket?

S: a in the first bracket and -4c in the second

T: Is that correct?

Ss: Yes sir

T: Now we can factorise each set separately (teacher wrote $a(3a+2b)-4c(3a+2b)$

T: We can now write (3a+2b)(a-4c) as the final answer

S: Sir we have two (3a+2b) why are we taking only one?

T: Since they are common to both expressions we take one. Is that ok?

Ss: Yes sir.

T: Ok we will solve some more examples in our next lesson.

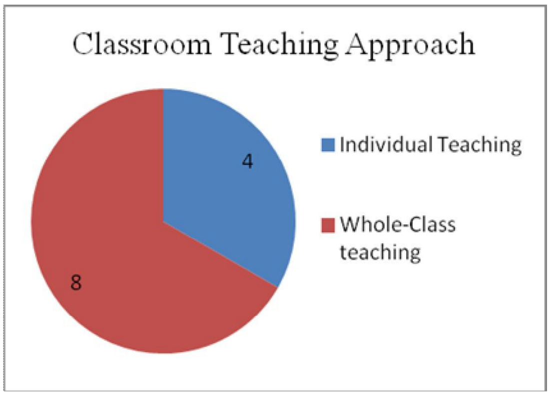


Figure 8. 31: Classroom Teaching Approach

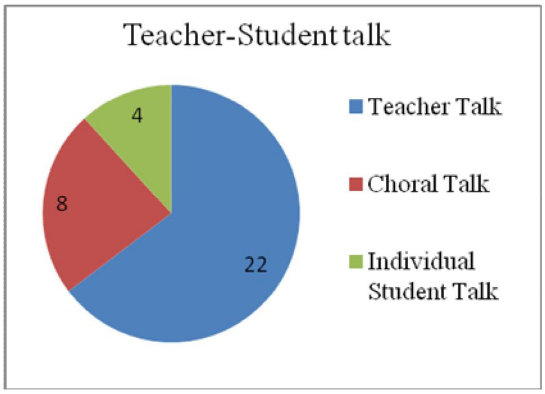


Figure 8. 32: Teacher-Student Talk

The observation data presented in Table 8.24 clearly demonstrates the sequence in which the lesson is presented. The teacher starts the lesson by reviewing students' existing knowledge through asking questions and uses demonstration and activity methods to develop students' understanding of the concept of factorisation. The delivery of the lesson is dominated by teacher-led activities, followed by students' responses to the teacher's questions. Students' participation in the teaching-learning process is encouraged through questioning, although most of the questions asked are factual questions which do not give the students the opportunity to critically think and explore in order to develop new knowledge (Boaler, 2009). The lesson is composed of whole-class teaching, as eight of the twelve students' responses are whole-class responses. Teacher-student interaction is limited to the few students who volunteer to answer the teacher's questions and student-student interaction is minimal, as each student is busy copying notes and keeping track of what the teacher is writing on the board; the only student-student engagement is when they compare their answers.

Interview Results

I conducted two individual interviews in this school with the two mathematics teachers whose lessons were observed (see Tables 8.25 and 8.26) and six individual interviews with students. The results and findings from the interview data are presented in this section.

Teachers' Interview Reports and Analysis

Table 8. 25: Interview Reports and Analysis

Interviewer (I): How do you normally start your lessons? **Teacher D (TD):** I start by reviewing students' related knowledge **I**: How will you define teaching well? **TD:** Teaching well involves helping students to develop an understanding of a particular concept through the use of appropriate teaching methods **I**: Ok, which methods do you consider to be appropriate? **TD**: Methods that promote students' active participation such as activity and demonstration methods **I**: Ok so are these the methods you normally use? **TD:** Yes **I:** So under what circumstances would you say you have taught well? **TD:** Oh it all depends on the feedback I get from my students. If I get positive feedback then it means I have taught well **I**: So what is your main priority when teaching mathematics? **TD:** Oh to promote students' understanding **I**: How do you achieve this?

TD: Through the use of a variety of teaching methods to cater for the individual student's learning style. **I**: So what do you think is the best way of teaching mathematics? **TD**: I do not think there is only one best way, but involving students' in the teaching-learning process is the best **I**: So how do you promote students' participation? **TD**: Through questioning and activity group work **I:** In your view what is the best way of learning mathematics? **TD**: Practicing

Table 8. 26: Interview Report of Teacher E

Interviewer (I): How do you normally start your lessons? **Teacher E (TE):** I first review students' related knowledge. **I**: How will you define teaching well? **TE:** Teaching to students' understanding. **I:** So under what circumstances would you say you have taught well? **TE:** It depends on the responses you get from the students. If they are able to solve the questions given to them then we can say I have taught well **I:** What are your main priorities when teaching? **TE:** Understanding, because a lot of people see mathematics as a difficult subject **I:** So what method(s) do you normally use when teaching? **TE**: Activity method **I**: Why do you use this method? **TE:** You know most people do not like mathematics and the best way to encourage their participation is through the use of teaching methods which promote participation **I**: Ok, so how do you encourage students' participation in your lessons? **TE**: Through questioning **I**: So what do you think is the best way of teaching mathematics? **TE**: Hmm, I am not sure if there is any single best way, but I think the use of an appropriate method and resources is the way out **I**: What do you mean by an appropriate method? **TE:** Oh, by an appropriate method, I mean a method that is suitable for achieving the set target for

the lesson.
I: So do you mean the objectives of the lesson determine which method to use?
TE: Yes
I: So do you mean you do not just use the activity method?
TE: Yes, but I always try as much as possible to combine the activity method with other methods because I believe that mathematics is a practical subject and the activity method helps students a lot
I: So in your view what is the best way to learn mathematics?
TE: Hmm, there is no best single way, but developing a positive attitude towards the subject, practicing I think is the way out

Teacher D has nine years teaching experience and has been teaching mathematics for the past two years. Teacher E has been in the teaching profession for five years and has been teaching mathematics for the past four years. According to Boaler (2008), allowing students to explain their answers and asking them probing questions gives students the opportunity to be actively engaged in the teaching-learning process, to develop new knowledge and to gain understanding. From the above reports, it is clear that both teachers share a common priority, namely promoting students' understanding when teaching. Both teachers agree that they promote students' active participation in the teaching-learning process through questioning.

Willis (2010) argues that students' mistakes and misconceptions are part of their learning process and assisting students to overcome these issues provides opportunities for conceptual learning and the construction of new knowledge. It is interesting to note from the above reports that both teachers believe that when their students are able to provide correct answers it means they have taught them well. It is thus clear that students' mistakes are not encouraged, even though such mistakes and misconceptions are part of the teaching-learning process. This perception is consistent with the results from the teachers' questionnaire, as both teachers indicate that they explain things carefully to their students to prevent them from making mistakes.

Students' Interview Results and Analysis

The individual interview responses from the six students are analysed under the following headings: reasons for learning mathematics, students' participation, students' views regarding what it takes to be successful when learning mathematics and students' preferred ways to learn (see Table 8.27).

Table 8. 27: Students' Interview Responses - School D

Interview Questions/Themes	Descriptions and Examples from Interview Data
How often do you learn mathematics and why?	Formulae- difficult to comprehend the many formulae Interest – because mathematics is an interesting subject Occupational aspirations- relevant to what the kind of job they want to do in future e.g. medical doctor Weak- they think they are weak in mathematics Favourite- because it is their favourite subject
If you know the answer to a question will you volunteer to answer it?	Yes – but when they are confident the answer is correct Yes – but when called by the teacher
What happens if you give a wrong answer?	Correction – the teacher will correct them Mocked - their colleagues will laugh at them Rethink- will think about the question and correct themselves
How do you feel when you give a wrong answer?	Shy – as their colleagues may mock Unhappy- it brings their confidence level down Ashamed- will look like they have not been paying attention in class Indifferent – does not affect them in any way
What does it take to be successful when learning mathematics?	Practicing- following teachers' methods Other methods – looking for alternative methods Listening - listening to the teacher and following his method Serious- they think one has to be serious to be successful in maths
Why do you prefer to learn alone?	Examination- during the final examination there is no group work Confusion - The become confused when working in a group
Why do you prefer to learn in groups or with colleagues?	Understanding- they understand well when they learn together Confident- their colleagues will correct then when they are wrong. Correction – they can be corrected by their colleagues Variety of ideas- can learn from each other and get new ideas

Why Students' Learn Mathematics

The different reasons why students learn mathematics given by the six interviewees are collated and categorised into: interest, difficulty, occupational aspirations, confidence and a favourite subject (see Figure 8.33).

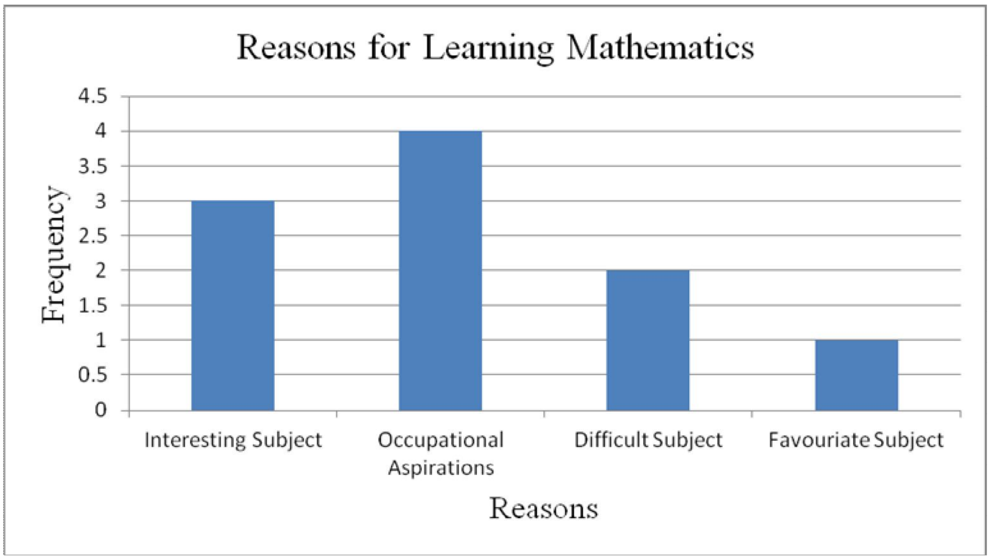


Figure 8. 33: Students Views about why they Learning Mathematics

From Figure 8.33, it is evident that there are a variety of reasons why students learn mathematics. The majority of the interviewees state that they learn mathematics because of the kind of jobs they want to do in the future. For example, one of the interviewees reports that she wants to be a medical doctor in future and thinks she will have to do well in mathematics to achieve this occupational aspiration. According to Fennema and Franke (1992) the way the teacher structures his/her classroom environment and his/her personal qualities as an individual play an important role in shaping students' learning experiences. Three of the interviewees state that they learn mathematics because they see the subject as interesting. When asked what makes the subject interesting, one retorts that the teacher is patient and he motivates them a lot. The other two agree that the teacher makes them aware of the utilitarian benefits they can derive if they study mathematics successfully.

Furthermore, two of the interviewees report that they learn mathematics because it is one of the most difficult subjects in the school curriculum. When asked why they see mathematics as the most difficult subject, they all indicate that they find it difficult to comprehend the many formulae and this suggests that the learning of mathematics goes beyond the imitation of mathematical formulae (Boaler 1998).

Students' Participation in Mathematics Lessons

When collecting data about students' participation in mathematics lessons, the six interviewees were asked if they were willing to volunteer to answer a question in class when they knew the answer and what happens when they give a wrong answer. This section therefore presents the interviewees' responses regarding their willingness to participate in their mathematics lessons (see Figure 8.34).

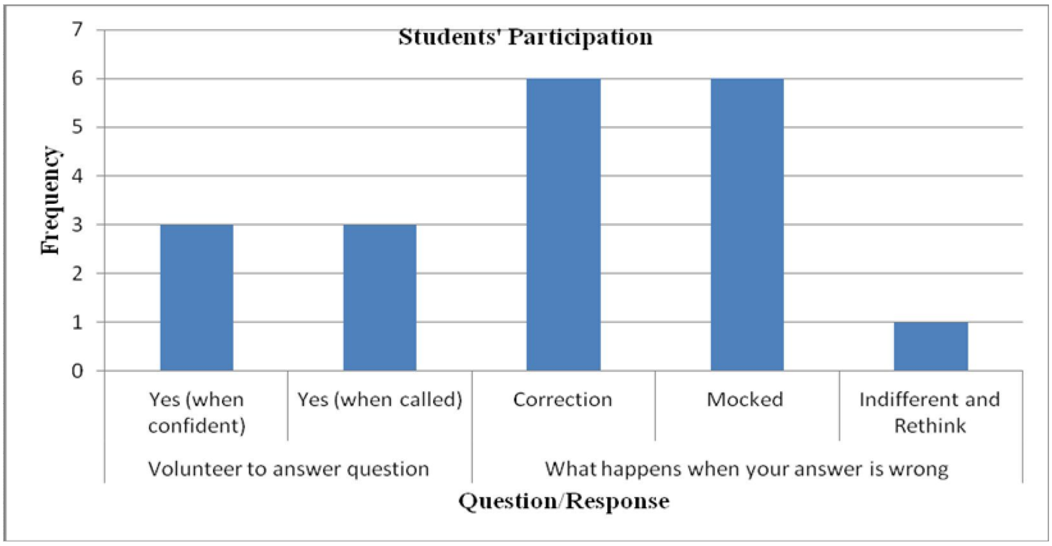


Figure 8. 34: Students' Willingness to Participate

Figure 8.34 reveals that all the interviewees are enthusiastic about answering questions in class. However, it is interesting to note that, despite their willingness to answer questions, three of the interviewees report that they will only volunteer to answer a question in class if they are confident that their answers are correct. The other three interviewees also agree that, although they are enthusiastic about answering a question in class, they prefer not to be called by the teacher as they are not sure of their answers. This therefore suggests that mistakes are something all the students try to avoid. All the interviewees state that their colleagues will mock them when they make a mistake and they all believe that the teacher will correct them. The results, with the exception of one student who says that she feels indifferent when she gives a wrong answer and will rethink the question and answer again, suggest the individual student's participation in the teaching-learning process is influenced by the feedback they receive from their peers.

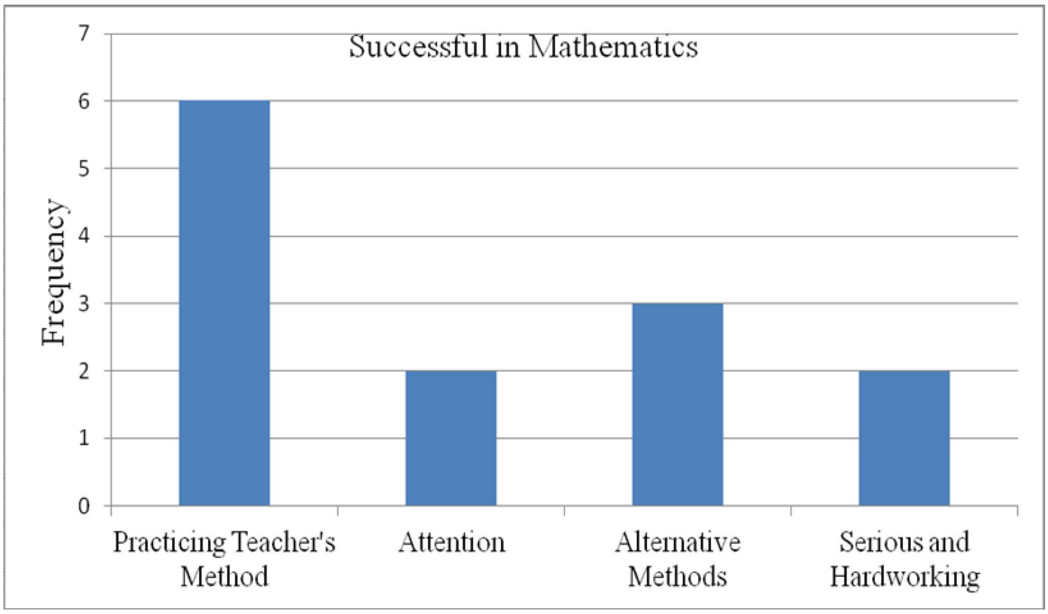


Figure 8. 35: What it takes to be successful in Mathematics

Many students' experiences of learning mathematics are shaped by following the teacher's method and this does not give students the opportunity to take responsibility for their own learning (Boaler and Greeno 2000). Figure 8.35 shows that the students experience mathematics in a passive way and see their teacher as a custodian of knowledge, relying on their teacher's approach and methods of solving questions. However, the results also show that some of students do not only rely on the teachers' method, but also look for different methods of solving problems. When asked why they think using alternative methods helps in becoming successful in mathematics, one of the interviewees reports that looking for different methods gives you the opportunity to explore different ways of investigating or solving a problem.

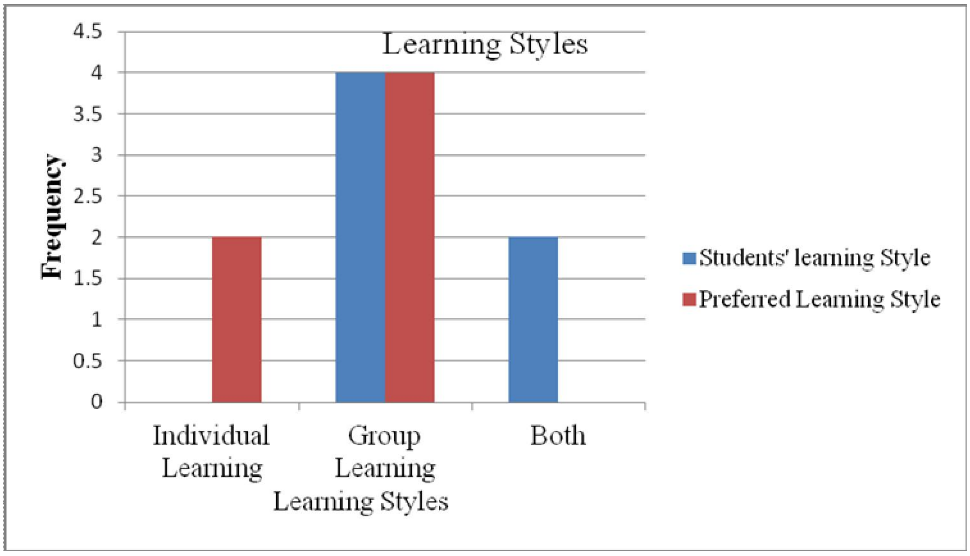


Figure 8. 36: Students' Preferred ways of Learning

Discussions among students and working in groups promotes and extend learners mathematical understanding and students are able to retain their knowledge for a longer period of time when they interact or learn from one another (Elbers 2003). Figure 8.36 reveals that the majority of the interviewees prefer and appreciate the importance of group work in developing new ideas and knowledge. For example, all three who state that they prefer group learning claim that they absorb new ideas and further understanding when they work in a group. However, two interviewees agree that they prefer learning alone, although group work helps them to understand and learn more quickly.

When asked why, both students report that they prefer learning alone because the final examinations do not include any form of group work. This suggests that students acknowledge the importance and benefits of learning in groups, but the competitive nature of the school curriculum does not encourage students to work this way. Motivating students to develop a conceptual understanding of mathematics, rather than learning procedures for examinations, and the creation of a learning environment in which the individual student's views and ideas are acknowledged and respected are desirable aspects of group and independent learning.

Synthesis of Information

Overall, the analysis of the results from the quantitative data indicates that mathematics teachers use a variety of teaching methods to develop students' understanding and that the teachers have positive attitudes toward their teaching practices. The results also establish that the mathematics teachers in this school explain things carefully to students to prevent them from making mistakes and this is consistent with the results from all the other schools.

The qualitative data also reveals that students' participation varies from lesson to lesson; however, the majority of these students experience mathematics in a passive way following their teacher's instructions and methods. Similarly, during the classroom observations it was observed that most students were copying and listening as the teacher explained with minimum student-student engagement and teacher-student engagement. Finally, it was interesting that the majority of the students interviewed express their enthusiasm regarding answering questions in class if they know the answer, but their participation is always influenced by the kind of feedback they receive from their peers.

8.6 Summary

This chapter has presented the individual case analysis for the four case study schools by analysing both the quantitative and qualitative data from each school. This analysis reveals that students experience mathematics in different ways, but most of the students' experiences were controlled and directed by the teacher, who tells the students which question to attempt and which method to use.

The data also shows that most students participated in their lessons through the answering of factual questions. Among the four schools, the teacher's approach in school B was considered to be *exemplary* as students were given the opportunity to present and discuss their work in class. However, the students in this school described their teacher's teaching as purely teacher-centred. Finally, the research results presented in this chapter indicate that, although the majority of students are enthusiastic about answering questions in class, this willingness is stimulated or marred by the kind of feedback they receive from their colleagues.

The analysis of the data from the individual cases has provided information to answer the research questions that the present study seeks to resolve. The next chapter therefore presents a cross-case analysis of the results from the four case study schools in order to provide data to answer the research questions in detail.

Chapter 9

Cross-Case Analysis

9.1 Introduction

This chapter discusses the findings of this study by bringing together the results from the teachers' and students' surveys and the individual case studies to answer the research questions. It therefore provides a cross-case analysis by looking for similarities and differences between the survey and individual case results from the four case study schools in relation to the study research questions. Three symbols are used to represent the individual data sets. The plus sign (+) colour coded green indicates that a particular action or activity exists or there is a positive response; a minus sign (-) colour coded red is used to show a particular action does not exist or there is a negative response; and an asterisk sign (*) colour coded yellow means that an action was not fully present or absent or there is a partial response.

9.2 Research Question One

- **What teaching methods are used by mathematics teachers?**

The first research question seeks to examine the type of teaching methods that mathematics teachers use in their lessons. Both quantitative and qualitative data were collected to answer this question and Table 9.1 below summarises the quantitative and qualitative results from the four case study schools.

Table 9. 1: Teachers Reported and Observed Teaching Methods

	Lecture Method		Activity Method		Demonstration Method		Group Work Method		Discovery Method	
	Quant	Qual	Quant	Qual	Quant	Qual	Quant	Qual	Quant	Qual
School A	*	*	+	*	+	-	+	-	+	-
School B	*	*	+	+	+	+	+	*	*	*
School C	-	*	+	*	+	*	+	-	+	-
School D	+	+	+	*	+	*	+	-	+	-

The quantitative data from the four schools establishes that teachers in schools A and B perceive that they sometimes use the lecture method during their teaching and the teacher in school C indicates that he never uses the lecture method. Teachers in school D also claim that they use the lecture method in their teaching and this is evident in Table 9.1. The qualitative data also provides similar results, as in schools A, B and C it can be observed that the teacher sometimes uses the lecture method, although the teacher in school C reported on the questionnaire that he never uses this method. This may have implications for the implementation of the new mathematics curriculum which outlines the activity method, demonstration method, group work and discovery methods as the prescribed techniques to be used, as the new curriculum is underpinned by the principles of constructivism.

Teachers' perceptions of their teaching are, however, consistent with national curriculum requirements, as the activity method, demonstration method and group work method are perceived to be the most favoured teaching methods. This result is consistent with the outcomes from the total sample of teachers (teachers' survey), as in both cases the lecture method is the least favoured teaching method and student-centred teaching methods are perceived to be used the most frequently. Teachers, similar to the findings from the total sample, do not rely on one particular teaching method, but use different techniques, with the activity method perceived to be the most popular.

The findings show that there are inconsistencies between teachers' perceptions of their teaching and how they actually teach. The majority of the teachers in the total sample and all the teachers in the four case study schools indicate that they use group work in their teaching; however, it has been observed that, apart from school B in which instances of students working in groups can be noted, this method is not common in the other schools. Most of the observed classroom episodes are characterised by a teacher-centred approach to teaching, with few student-student and student-teacher interactions. The qualitative data from the four case study schools shows that the perceived methods of teachers in schools A, C and D are inconsistent with the techniques they actually use. Although the teachers in these schools believe that they use a student-centred approach to teaching, their actual approach centres on procedure whereby students are presented with a series of formulae and steps that they need to follow to solve a particular question.

Another key point from the data is the fact that student-teacher engagement is centred on students answering the teacher's questions and most of these questions were factual and required only yes or no answers, with little critical thinking. It is also observed that in schools A, C and D the teachers randomly call students to the board to answer a question, but only those students who present correct answers are acknowledged. Only in school B is the teacher's perception of his teaching somehow consistent with his actual teaching. Although the teacher in school B starts his lessons using a teacher-centred approach, his technique is different as he makes use of concrete teaching-learning materials and connections to real life situations to increase students' understanding and engagement. In addition, students are given the opportunity to present their answers on the chalkboard and discuss their work with their colleagues.

In general, the results show that teachers acknowledge the importance of a student-centred approach to teaching and understand the national curriculum guidelines and its accompanying teaching methods. However, the implementation of these teaching methods is not consistent and many of these teachers rely more on their own teaching beliefs and methods than on the current trends in pedagogy.

9.3 Research Question Two

- **Why do mathematics teachers use these methods?**

The purpose of the second research question is to elicit teacher's views regarding why they use a particular teaching method. The data for this research question is drawn from the teachers' questionnaire and interviews. In the teachers' questionnaire, an open-ended question was used to discover why this is the case and, during the interviews, teachers were asked why they use a particular method of teaching in their lessons. The summaries of the findings are presented in Table 9.2.

Table 9. 2: Why Teachers' Use a Particular Teaching Method

School	Reported Method(s) of Teaching	Reasons for Using a Particular Teaching Method(s)	
		Questionnaire Data	**Interview Data**
School A	• Activity method • Demonstration method	• Understanding, • Inadequate materials	• Understanding • Interest
School B	• Activity method • Demonstration method • Discovery method	• Understanding • Engagement • Students background knowledge	• Efficient methods • Students perception • Practical subject • Individual difference
School C	• Activity method • Demonstration method • Discovery method • Lecture method (sometimes)	• Understanding • Individual differences	• Curriculum requirement • Time consuming • Students understanding
School D	• Activity method • Demonstration method	• Engagement • Understanding	• Engagement • Promote individual student's understanding

There are several reasons why teachers teach as they do and select the teaching method(s) they use. The literature indicates that teachers' instructional practices are largely influenced by their beliefs and conceptions of the subject. In contrast with previous research, the results from this study suggest that teachers' choice of a particular teaching method depends mostly on student related factors. In Table 9.2, increasing students' understanding is the common theme that is identified in both the data from the questionnaires and the interviews. In addition, encouragement of students' engagement in the teaching-learning process is another reason why mathematics teachers use a particular teaching method(s).

Students' background information such as existing knowledge and their perception of mathematics as a difficult subject also influences the teacher's choice. Some of the teachers report that most of the students they teach have insufficient mathematics background knowledge and the majority of these students believe that mathematics is a difficult subject. The teachers therefore indicate they look for a particular method or combination of methods to increase students' active participation and also cater to the individual needs of students.

Apart from student related factors, inadequate teaching material is a factor in why a particular teaching method is adopted. One of the teachers reveals that he is sometimes forced to use a teacher-centred method of teaching, since there are no teaching materials that help him to engage the students in activities or demonstrate a lesson using concrete objects. In addition, another teacher states that he sometimes uses the lecture method, as the other methods are time consuming and demanding considering the activities that they have to design for the students and the lack of teaching-learning materials. It is, however, interesting to note that, despite the majority of the teachers reporting that they use national curriculum prescribed teaching methods, only one teacher confirms that his choice of a particular teaching method is influenced by the national curriculum requirements.

In summary, despite the important role that the individual teacher's personal characteristics play in his/her instructional practices, the result from this study suggests that teachers place the needs of their students at the centre of their decision making. This implies that, although a teacher may hold behaviourist beliefs and his/her teaching may follow a teacher-centred approach, placing students at the centre of his/her decision making when choosing a particular teaching method can promote effective teaching and learning. The recognised benefits of these skills are that both the teacher and students are able to work in partnership to achieve set targets through the use of different teaching methods. This re-echoes Felder's (1993) assertion that all students do not learn in the same way and the use of different teaching methods based on the needs of students is necessary to ensure effective teaching and learning. The results therefore challenge teachers to be proactive in their teaching practices and vary their teaching methods to motivate and encourage students to develop an interest in the subject and to help individual students to develop their innate capabilities.

9.4 Research Question Three

- **Is there any relationship between teachers' perceptions of their classroom practices and what they actually do?**

The purpose of the third research question is to examine if there is any relationship between mathematics teachers' perceptions of their teaching practices and what they actually do in their respective classrooms. Table 9.3 presents a summary of teachers' perceptions of their teaching practices (quantitative (Qt) data from the teachers' questionnaire) and what they actually do (qualitative (Ql) data from the classroom observations).

Table 9. 3: Teachers' Reported and Observed Teaching Practices

	Statements from the Teachers' Questionnaire	School A		School B		School C		School D	
		Qt	Ql	Qt	Ql	Qt	Ql	Qt	Ql
Student-Led Climate (Constructivism)	I start each mathematics topic by reviewing students' prior knowledge.	+	+	+	+	+	+	+	+
	I go through a variety of methods when solving questions	+	-	+	+	+	+*	+	-
	I use different teaching methods when teaching	+	+*	+	+	+	+*	+	+*
	I use other textbooks and reference materials	+	-	+	+*	+	+*	+	-
	Students compare different methods of solving a question	+	-	+	+*	+	+*	+	-
	I ask students to work in small groups	+	-	+	+*	+	-	+	-
	I draw links between topics and move back and forth between topics	+	+*	+	+*	+	+*	+*	+*
	Students develop their own methods to solve problems	+	-	+	+*	-	-	+	-
Teacher-Led Climate (Behaviourism)	I explain things carefully to prevent students from making mistakes	+	+	+	+	+	+	+	+
	I give students the procedures to follow	+	+	+	+*	+	+	+	+
	I encourage students to use the method I teach them	+	+	+	+*	+	+	+	+
	I encourage students to work on their own	+	+	+	+*	+	+	+	+
	I ask students to complete easy tasks before attempting difficult ones	+	+	+	+	+	+	+	+
	I tell students which questions to attempt	-	+	+	+	+	+	-	+
	I teach each topic from the beginning, assuming my students know nothing	+	+*	+	+*	+	+*	+*	+*
	I go through one particular method for each mathematics question	-	+*	-	-	-	+*	+*	+*

Table 9.3 shows that there is some consistency between teachers' perceptions of their teaching and what they actually teach, although there are also some inconsistencies. For example, all the teachers indicate in the questionnaire that they start their lessons by reviewing students' related knowledge. The analysis of the classroom observation report reveals that there is a direct

relationship between teachers' reported perception of how they start their lessons and observed teaching practices. However, it is interesting to note that whilst teachers consider they review all students' existing knowledge, they actually review the knowledge of a few selected students. During the observation of all lessons, the reviewing of students' related knowledge was targeted on a few students and not the whole class. The responses from these few students who knew the answers to the teacher's questions were taken as the existing knowledge of the whole class.

The issue with this approach is that in most of the lessons observed it is the same group of people who answer most of the questions asked by the teacher. The teachers try as much as possible to actively involve the students in the teaching-learning process through questioning and by so doing concentrate on the few students who know the answers to the questions. It is also evident from Table 9.3 that the majority of the teachers indicated in the questionnaire that they use a combination of different teaching methods. Similarly, the interview reports from the individual schools also establish that most teachers are of the view that they normally combine activity, demonstration and group work methods in their teaching. The analysis of the classroom observation data, however, reveals that although the teachers use a combination of different methods of teaching, these different methods were limited to demonstration and lecture methods and sometimes the activity method. From the interview reports and the answers from the open ended questions in the teachers' questionnaire, it is clear that the purpose of using different teaching methods is to involve students in the teaching-learning process and also cater for the individual student's needs. However, since students' participation in the teaching-learning process is through answering the teacher's questions in most cases, and this targets only a few students, the majority of the students listen and copy notes from the board.

As discussed in Chapter one, the recommended teaching method in the mathematics curriculum in Ghana is the use of co-operative learning whereby individual students can work with their peers to develop new knowledge and take responsibility for their own learning (MoESS 2007). The results from the classroom observation reveal that the teacher's perception of their teaching regarding the encouragement of group work is different from what they actually do in their respective classrooms. The classroom observation results from individual lessons reveal that most of the students work individually in most lessons. The only time students talk to one another is when they compare their answers. However, it is interesting to note that, in schools B and C, although the teacher-centred approach is mostly used, students' participation is encouraged and stimulated since students are given the opportunity to present and explain their work.

In general, although teachers perceive and acknowledge the importance of a student-centred approach to teaching, their actual teaching differs considerably. Teachers' perceptions of their teaching practices relating to teacher-centred approaches are more consistent with their actual teaching practices than their perceptions relating to student-centred approaches to teaching and this is evident from Table 9.3. The results also establish that teachers try to prevent their students from making mistakes by explaining things carefully, despite the fact that students' mistakes and misconceptions are part of the teaching-learning process, as argued by Willis (2010). There is no difference between teachers' perceptions of their teaching regarding encouraging students to avoid mistakes and what they actually do in class.

9.5 Research Question Four

- **What are students' perceptions of their teachers' teaching?**

Table 9.4 presents a summary of students' perceptions regarding their teachers' teaching practices.

Table 9. 4: Students' Perceptions of their Teachers' Teaching

Climate	Statement	All Schools (n=358)	School A (n=32)	School B (n=30)	School C (n=30)	School D (n=30)
		Percent/ Type	***Percent/ Type***	***Percent/ Type***	***Percent/ Type***	***Percent/ Type***
Student-Led Climate (Constructivism)	The teacher expects us to learn through discussing our ideas in class	90 (Agree)	100 (Agree)	73 (Agree)	80 (Agree)	77 (Agree)
	The teacher asks us to compare different methods for solving questions	87 (Agree)	94 (Agree)	77 (Agree)	90 (Agree)	83 (Agree)
	The teacher encourages us to make and discuss our mistakes	84 (Agree)	97 (Agree)	93 (Agree)	83 (Agree)	73 (Agree)
	The teacher asks us to work in pairs or small groups	77 (Agree)	94 (Agree)	63 (*)	67 (*)	77 (Agree)
	The teacher encourages us to invent and use our own methods	54 (*)	81 (Agree)	57 (*)	50 (*)	93 (Disagree)
Teacher-Led Climate (Behaviourism)	The teacher prevents us from making mistakes by explaining things carefully	97 (Agree)	97 (Agree)	97 (Agree)	93 (Agree)	100 (Agree)
	The teacher asks us to work through practice exercises	94 (Agree)	94 (Agree)	97 (Agree)	93 (Agree)	87 (Agree)
	The teacher shows us which method to use and then asks us to use it.	92 (Agree)	97 (Agree)	97 (Agree)	73 (Agree)	97 (Agree)
	The teacher tells us which questions to attempt	92 (Agree)	94 (Agree)	93 (Agree)	97 (Agree)	93 (Agree)
	The teacher expects us to follow the textbook closely	74 (Agree)	87 (Agree)	97 (Agree)	77 (Agree)	50 (*)

From Table 9.4, it is clear that the majority of students ascribe a high percentage score to both teacher-centred and student-centred approaches to teaching. However, the proportion of students who describe their teachers' teaching as teacher-centred was higher than those who describe their teachers' teaching as student-centred. This suggests that most teachers often use a teacher-centred approach to teaching, as compared to a student-centred approach. In all cases, most of the students confide that the teacher tells them which method to use and which question to answer. In addition, the majority of students indicate that the teacher shows them which method to use most also report that the teacher tries to prevent them from making mistakes by explaining things carefully. These findings are consistent with the findings from the teachers' questionnaire, as the majority of teachers also indicate that they tell their students what to do and encourage their students to try as much as possible to avoid making mistakes.

In summary, the results show that, although a student-centred approach to teaching is not completely ignored, students are taught mathematics in a structured and procedural way whereby they have to follow and apply the teachers' instructions and practices. In addition to this, the results reveal that students perceive their teachers as active members of the teaching-learning process rather than facilitators. The results suggest that, in all cases, the implementation of the principles of constructivism as stipulated in the national curriculum have not been fully conceptualised in the classroom discourse. Many of the students perceive the teacher as the custodian of knowledge and they mostly rely on the teacher for the acquisition and creation of new knowledge; these are contentious areas for improvement.

9.6 Research Question Five

- **What are students' experiences of being taught mathematics?**

Table 9.5 presents a summary of students' perceptions and views regarding their learning experiences. The data used have been drawn from the students' questionnaire, classroom observations and individual interviews with the students.

Table 9. 5: Students' Learning Experiences

	Statements from Students Questionnaire	School A		School B		School C		School D	
		Qt	Ql	Qt	Ql	Qt	Ql	Qt	Ql
Active Learning Strategies (Constructivism)	I discuss my ideas in a group or with a partner	+	+*	+	+*	+	+*	+	+*
	I compare different methods used to solve questions	+	-	+	+*	+	+*		-
	I ask the teacher questions whenever I do not understand	+	+	+	+	+	+	+	+
	I look for different ways to attempt the question.	+	-	+*	+*	+	+*	+*	+*
	I make up my own questions and methods	+	-	+	-	+*	-	+*	-
Passive Learning Strategies (Behaviourism)	I listen while the teacher explains	+	+	+	+	+	+	+	+
	I copy down the method from the board or textbook	+	+	+	+	+	+	+	+
	I attempt easy problems first to increase my confidence	+	+	+	+	+	+	+	+
	I only attempt questions I am told to do	+	+	+	+	+	+*	+	+
	I work on my own	+	+	+	+*	+	+*	+	+

Felder (1993) believes that individuals and, for that matter, students vary considerably in how they construct their information to test their understanding, knowledge and skills. In a similar way, students also vary considerably in how they experiences mathematics in their classrooms. The review of the literature has distinguished passive and active experiences in the literature and the questions to measure students' experiences were built around these two forms of experience. It is evident from Table 9.5 that the analysis of the quantitative and qualitative data from the four schools indicates the majority of the students experience mathematics in a passive way, with little or no form of critical thinking and independent learning. For example, Table 9.5 shows that all the students reveal in the questionnaire that they normally listen while the teacher explains. Similar to the students' perceptions, the classroom observation data also confirms that in most of the lessons students sit down quietly, listening to the teacher and coping notes from the board.

Previous research (Boaler 2006; Mapolelo 2009) discloses similar findings, namely that in most classrooms students are seen to emulate their teachers' procedures and approaches and gain approval for finding the correct answer to a question rather than making sense of mathematical concepts and skills. Table 9.5 also confirms that the learning experiences of the students are controlled by the teacher, who tells them which question to answer and what method to use; this is also consistent with the results obtained from the students' interviews. For example, the analysis of the students' interviews in Chapter eight reveals that, when asked what it takes to be successful when learning mathematics, the most common answers given by the students are paying attention in class and following the teacher's approach and methods. Also, most of lessons observed reveal that the majority of the students consider their teacher to be the custodian of knowledge and his approach and methods of solving problems were adopted by the students without any questions or need for explanations.

Similarly, individual work among students is also common in all the four schools and the observation results reveal that the only time students are seen working in groups is when they are comparing their answers. On the other hand, all the students indicate that they discuss their work in groups or with colleagues and compare different methods of solving problems. This suggests that aspects of the students' learning experiences could be classified as constructivist in nature. However, an analysis of the classroom observation data reveals that, apart from school B in which students have the opportunity to discuss their work and gain feedback from their colleagues and the teacher, group work has not been observed in any of the lessons. However, it is interesting to note that, during the interview conversation, the majority of the students confide that they prefer to work in groups, as group work stimulates their understanding and interest and helps them to learn faster.

This echoes Hodson's (1993) suggestion that the best way to learn mathematics is through active interaction with colleagues and the teacher.

Similar to the results from the individual schools in Chapter 8, Table 9.5 also shows that the students are enthusiastic about asking and answering questions in class; this is supported by both quantitative and qualitative data. The majority of the students reveal in the questionnaire that they ask questions in class and during the classroom observation most students are seen to volunteer to answer questions when the teacher asks a question. However, the analysis of the individual interview reports that students are willing to volunteer to answer questions in class if they know the answer is informative. It is interesting to note that the majority of the students agree that their willingness is influenced by the type of feedback they receive from their colleagues, as in most cases their colleagues mock them when they give a wrong answer.

The results reveal that giving wrong answers is something that most students try to avoid because they are afraid of being ridiculed by their colleagues; such situations do not motivate students to become actively involved in the teaching-learning process. For example, during the interviews, the majority of students indicate that they become less motivated when they give a wrong answer and prefer to remain silent in class. The results therefore show that, although the teacher plays an important role in shaping students' experiences of learning mathematics, the kind of feedback that the individual student receives from his/her colleagues affects the individual student's participation in the teaching-learning process. It can therefore be concluded that there is a need for a classroom environment free from fear and intimidation to promote students' active participation. Furthermore, students' misconceptions and mistakes should be considered to be part of the teaching-learning process and students ought to be encouraged to discuss their mistakes and misconceptions to promote active participation in the teaching-learning process.

9.7 Summary

This chapter has presented a summary of the analysis of the data collected from the four case study schools in order to answer the research questions raised. Several key issues have been discussed in this chapter; firstly, the results revealed that teachers use different teaching methods. The common methods that the majority perceived they were using were the activity and demonstration methods. Although there were some discrepancies between teachers' perceived and actual teaching practices, it was interesting to note that teachers' choice of a particular method was greatly influenced by the needs of the students. Secondly, the results showed that, although the teacher-centred approach was the most common choice, it became clear that all the teachers displayed some aspects of teaching that could be classified as student-centred in nature. The results therefore indicated that the teacher played an active role in the teaching-learning process and these teaching skills have been criticised as not giving students the opportunity to develop and construct new knowledge. However, the majority of the students were more familiar and comfortable with this approach and needed the active involvement of their teacher to trigger their learning.

Finally, despite the active role that the teacher plays in shaping students' learning experiences, feedback from other students also had a greater impact on the individual student's learning experiences. A significant proportion of the students indicated that they ask and answer questions in class; however, the majority of those interviewed disclosed that, despite their willingness and enthusiasm to answer questions, the feedback they received from their peers influenced their level of participation in class. This summary suggests that teachers and students ought to work as partners in the creation of new knowledge. Students' perceptions of the teacher as the custodian of knowledge puts pressure on the teacher to control most of the classroom activities, as compared to acting as a facilitator of the teaching-learning process. The next chapter, Chapter 10, will present the discussion and summary of the findings and the contributions of the present study to the field of mathematics education.

PART V: CONCLUSIONS AND FURTHER RESEARCH

Chapter 10

Conclusions and Implications

10.1 Introduction

This chapter concludes the study by discussing the findings of the study presented in Chapter 7 to Chapter 9. In general, the purpose of this chapter is to discuss how the findings from the study answer the research questions posed in Chapter 1, and how the study contributes to knowledge in relation to the existing literature.

The chapter is divided into six sub-sections and it begins by revisiting the purpose of the study and the research questions. The second sub-section summarises the key findings from the research and the third discusses the possible contribution of knowledge to the field of mathematics education in general and, more specifically, to the teaching and learning of mathematics in Ghanaian Junior Secondary Schools. The fourth sub-section outlines the limitations of the study and the fifth discusses the implications of the findings from this study for further research. The last sub-section presents a summary of the present chapter.

10.2 Revisiting the Study Purpose and Research Questions

This research was necessitated by my personal experiences as a student, educator and researcher, as well as the ongoing debate relating to the teaching and learning of mathematics. As discussed in Chapter 1, a new mathematics curriculum was introduced in Ghana in 2007 with the aim of enabling students to acquire the mathematical skills, insights, attitudes and values that they will need in order to be successful in their chosen careers and daily lives. To achieve this, the new curriculum places emphasis on students' active participation in the teaching-learning process. By 2010, when the present study was conducted, no study had investigated the teaching practices and learning experiences of students that have arisen as a result of the curriculum reforms. The present study set out to find answers to the following research questions:

1. What teaching methods are used by mathematics teachers?
2. Why do mathematics teachers use these teaching methods?
3. Is there any relationship between teachers' perception of their classroom practices and what they actually do in class?
4. What are students' perceptions of their teachers' teaching practices?
5. What are students' experiences of being taught mathematics?

10.3 Summary of the Findings

Mathematics Teachers' Classroom Practices

Teachers' Teaching Methods

According to Anthony and Walshaw (2007), two teaching methods are distinguishable in the literature: teacher-centred and student-centred approaches. The teacher-centred approach is characterised by situations in which the teacher acts as an instructor and takes full control of the teaching-learning process, telling the students what to do. A student-centred approach, on the other hand, is represented by situations in which the teacher acts as a facilitator by giving students the chance to actively participate in the teaching-learning process (Anthony and Walshaw 2007).

The results from this study show that the teacher-centred approach to teaching was common in all schools, although there were instances where a student-centred approach was used. The results also reveal that teachers' perceptions of the teaching methods they use were consistent with national curriculum requirements. The majority of the teachers indicated that they use activity and demonstration methods frequently for several reasons. Although the literature suggests that the choice of a particular teaching method is dependent on the teacher's subject content knowledge and beliefs, the results from the present study have also revealed that students' understanding, the background characteristics of students, inadequate teaching-learning materials and the individual teacher's priorities when teaching influence the choice of a particular method. This result suggest that most teachers were largely interested in looking for a method that helps the individual student to develop and construct new knowledge.

The summary of the study results revealed that mathematics teachers do not use one particular teaching technique, but use a combination of various teaching methods. The quantitative data from the questionnaire revealed that teachers follow teacher-centred approaches such as the traditional lecture method and drill method, as well as student-centred approaches such as activity and demonstration methods. The results from the classroom observation and the individual interviews also established that the use of the teacher-centred approach was paramount in most of the lessons observed. However students' engagement and participation in the teaching-learning process was not completely ignored as claimed by Fletcher (2005) in his study of mathematics classroom practices in Ghana. The result of the classroom observation presented in Chapters 8-9 have shown that, in all 10 lessons observed, students' participation in the teaching-learning process was encouraged by the teacher through questions and demonstration. However, in most cases, these questions were factual and did not require any form of critical thinking from the students, although there were instances in which teachers used probing questions which helped students to extend and apply their knowledge.

Reasons why Teachers' use a Particular Teaching Method

In this present study it became clear from the analysis of the questionnaire, classroom observations and the individual interviews with the teachers that each teacher's method of teaching is influenced by different factors. For instance, it was observed that the choice of a particular teaching method was influenced by the teacher-factor, curriculum specification, resources and, more importantly, the student-factor. All five teachers who were interviewed reported that they place their students at the centre of their decision making when deciding which teaching method to use for a particular topic. That is, they acknowledge that promoting students' understanding and participation in the teaching-learning process involves choosing a suitable teaching method. Taking care of the individual student's learning needs is an important implication of the constructivist approach to mathematics teaching and learning.

Teachers' Reported and Observed Teaching Practices

Teachers' perceptions and beliefs regarding their teaching and learning are, in general, central to what they actually do in their respective classrooms (Ernest 1989). For example, Perkkila (2003) and Pepin (1999) report that mathematics teachers' perceptions of their classroom practices are consistent with their actual classroom practices. In this present study, the results showed that mathematics teachers' perceptions of their classroom practices were not wholly consistent with what they actually do. For instance, all the teachers who completed the questionnaire indicated that they use a variety of methods to solve problems during their mathematics lessons. Although a student-centred approach was used in some cases, during the lessons a teacher-centred approach to teaching dominated most of the lessons observed. Students were seen to be rehearsing and memorising formulae and procedures for solving problems rather than developing a conceptual understanding of the concepts and skills presented.

Also, all the teachers indicated in the questionnaire that they encouraged their students to work in groups during lessons. However, the findings from the classroom observation data were inconsistent with these perceptions, as individual work was standard practice among students and the only time that students were involved in discussion was when they were comparing answers. This suggests that, as much as teachers are aware of the requirements the national curriculum, the majority of these teachers have not been able to fully conceptualise these ideas and requirements in their classroom discourse. In general, although most of the teachers professed that they used a student-centred approach to teaching; teacher-centred methods were most often used.

Teachers' Speech and Explanations

Teachers' speech and how the teacher communicates a given concept to students play an important role in shaping students' learning experiences (NCES 1999). The results in Chapter 8 have shown that, in all the lessons observed, the proportions of speech by teachers were higher than that of students and the only time that students were seen talking was when they were answering the teacher's questions or when a student was called to the board to present and discuss their work. In classrooms in which students' participation is constrained by the quantity of their teacher's speech, students normally experience mathematics in a passive way with little or no opportunity to develop and create their own knowledge (Mercer 1995). For example, the analysis of the classroom observation data established that the majority of the students listened and copied notes as the teacher spoke and explained. That is why most of these students passively experience mathematics and this was affirmed by the students' interviews, as most of the students indicated that they have to follow the teachers' methods and strategies in order to be successful in mathematics.

Students' Perceptions of their Teachers' Teaching

The findings regarding students' perceptions of their teachers' teaching were consistent with their teachers' perceptions of their own teaching. The majority of the students indicated that their teacher explains things carefully so as to prevent them from making mistakes and this was consistent with the teachers' perceptions of their teaching. Most of the students also reported that their teacher encourages them to avoid making mistakes, although the literature has shown that students' mistakes and misconceptions are part of the teaching-learning process (Willis 2010). The recognised effect of these teaching skills is that, in such classrooms, students are not given the opportunity to develop new knowledge using their own initiatives and explore different avenues (Boaler 2003; Willis 2010).

Moreover, the majority of the students revealed that their teacher tells them which question to answer and which method to use and how to approach a question. Similarly, many of the students also indicated that they are encouraged to discuss their ideas in a group, but they are not motivated to invent their own method of solving problems. This was consistent with the teachers' perceptions of their teaching, as almost all the teachers stated that they tell the students which formulae to use when solving a particular problem.

Students' perceptions of their teachers' teaching therefore suggests that teachers often use a teacher-centred as compared to a student-centred approach and this technique does not encourage the participation of students in the teaching-learning process (Boaler and Greeno 2000; Boaler 2003). This result, therefore, challenges teachers to be innovative in their teaching and, if possible, to use students' input as feedback when reflecting on their teaching and their promotion of effective learning among students. The findings from this study challenge teachers to stimulate active participation and independent learning among students, as students' role in the classroom is no longer passive; they are active members of the teaching and learning process (Ahmad and Aziz 2009).

Students' Learning Experiences

In Chapters 8 and 9, it was discussed that individual students learn or experience mathematics differently and in varying ways. The results from these chapters have shown that, despite the fact that students experience mathematics differently, the majority experience mathematics in a passive way whereby their experiences are influenced and shaped by their teacher's actions. Students' responses from the questionnaire and the interviews showed that students perceived their teacher as the custodian of knowledge. This was evident in the students' interviews, since most students reported that, in order to be successful in mathematics, one must use the teacher's approach to solving problems and follow the teacher's instructions. In general, as discussed in Chapters 7-9, the results from the study showed that the individual student's experience of learning mathematics was influenced by two main factors: the teacher factor and the student or peer factor.

The results revealed that, to a large extent, the individual student's learning experiences are influenced by their teacher, who tells them which question to answer and what method to use. Similarly, the results also showed that in almost all the lessons observed the teacher was seen as the custodian of knowledge and students accepted the teacher's approach and methods of solving problems without question. The findings from this study therefore corroborate previous studies that have found the learning experiences of individual students are directly influenced by the teacher (e.g. Boaler 2003; Willis 2010).

The results from this study confirm that the other major factor which shapes and affects students' experiences of learning mathematics is peer pressure. During the interviews, all the students expressed their willingness to answer a question if they know the answer and thus participate in the teaching-learning process. However, it was interesting to note that the majority of students interviewed reported that the kind of feedback they get from their colleagues affects their learning experiences. It was observed that supplying wrong answers in class leads to been mocked by peers and the respondents indicated that this affects their levels of confidence and their willingness to participate in class. The result was that only those students who were confident of themselves and knew the correct answers were willing to answer a question in class. In Ghana, very little is known about the impact of peer pressure on students' learning experiences and the results from the present study therefore bring to light the need for empirical research on the impact of this factor on students' learning experiences.

10.4 The Contributions of this Research

As discussed in Chapter 1, I found that no study in Ghana has investigated the teaching and learning of mathematics in Ghanaian Junior High Schools since the introduction of the new curriculum in 2007. In this respect, the findings of this study contribute to the understanding of how mathematics is taught and learned in Ghana. Moreover, I could not find any account of research on mathematics teaching and learning, even outside Ghana that answers the research questions posed by this study using similar methods of sampling, data collection and analysis procedures. The study therefore contributes to the field of mathematics education at the national (Ghana) and international levels.

The results and discussions provided several insights and answers that were consistent with the existing literature. For example, the teaching practices of most of the teachers were consistent with those described in the literature. Students' experiences of learning mathematics were, to some extent, also consistent with those discussed in the literature. In addition, other results and discussions from the study have added new insights into the field. I found that, inasmuch as the literature suggests that the teacher has a greater influence on students' learning experiences, the feedback that students receive from their peers also has a significant impact on students' learning experiences. All the students interviewed indicated that the kind of feedback they get from their colleagues has a greater influence on their participation in the teaching-learning process.

In addition to this, the debate on mathematics teaching and learning has been triggered by the need for a change in instructional practices from a teacher-centred approach to a constructivist approach which is more student-centred. However, the movement towards a more constructivist approach was not evident in most of the classrooms observed. The present study therefore argues that, although mathematics teachers may possess in-depth knowledge about the national curriculum requirements and the possible changes, its implementation is problematic. This proposition corroborates the views and ideas obtained from the students' interviews, as the majority of students still rely on the teacher as their main source of knowledge acquisition and see the construction of their own knowledge as 'impossible' without help or guidance from their teacher. The findings support the conceptual framework of the study, and I propose the enactivist theory, which advocates partnership between teachers and students in the classroom, as the new paradigm for teaching that must be considered within the Ghanaian context.

10.5 Limitations of the Research

One major limitation of the present study was the relatively small sample size used. The study was conducted in only one of the 170 districts in the country and the participants were drawn from only 12 of the 72 junior secondary schools in the metropolis. Although the sampling technique used increased the maximum variation of the study sample, the inclusion of more districts would have ensured the involvement of a larger number of participants to provide a more representative view which could be generalised to a larger population. However, despite the above limitation, some of the findings from this study support the findings of other researchers in the field of mathematics education (e.g. Boaler 2003; Willis 2010). Another limitation of this study was the issue of sampling selection. The technique used to select the students was not ideal. All the students who participated in the research were randomly selected with the help of the class teacher. Although all the students were aware that their participation was voluntary, none of them declined to participate.

The issue of researcher bias was another limitation. My beliefs about mathematics teaching and learning and my experiences as a mathematics educator gained from teaching and being taught in different countries was an issue of concern. I brought different ideas from different countries and there was the possibility that these differences in teaching may impact on the success of the study. However, to guard against these biases, I made conscious efforts to remain as objective as possible during the data collection, analysis and dissemination of the study findings.

In addition, the limitation caused by the “Hawthorne Effect” was another issue of major concern. As the participants are liable to change their behaviour is they know that they are been observed, I first made familiarisation visits to all the schools to become acquainted with my subjects. Moreover, the ‘Hawthorne Effect’ was minimised through the use of different instruments and respondents in the collection of similar information. In this study, three data sources (a semi-structured questionnaire, observation and semi-structured interviews) were used to collect similar data and this permitted the study of the same phenomenon whereby the weakness of one method was nullified by the use of a different method.

10.6 Implications and Directions for Further Research

Despite the limitations discussed above, the findings from this research raise some significant issues relating to the teaching and learning of mathematics in Ghana. The present study provides mathematics teachers with new ideas in encouraging and stimulating students’ active participation in the teaching-learning process in fulfilment on the trends in mathematics education. The findings also provide some useful information for mathematics teachers' and challenges them to be proactive in promoting a classroom environment free from intimidation and fear to motivate more students to be actively involved in teaching-learning process. This calls on teachers and students to understand and see mistakes and misconceptions as part of the learning process and correcting such mistakes and misconceptions leads to the creation of new knowledge.

The results also provide some useful information to education authorities and curriculum developers. In essence, the results put into question the adaptation of a constructivist approach of teaching and learning of mathematics as indicated in the national curriculum and therefore provide a strong indication that, the adoption and implementation of this policy initiative in the Ghanaian context is problematic. Teachers' are still considered as the custodians of knowledge in most classrooms by students and these students have the impression that their success in mathematics depends on their ability to follow their teacher's instructions and approaches of solving problems. This calls on education authorities to organise in-service training programmes and courses for teachers on how to stimulate independent learning among students'. Likewise, this calls for workshops and guidance sessions for students' on the importance of independent learning as a tool for making informed judgement and the application of the concepts learnt to real life situations.

From the policy perspective, the results from this study also questions the realisation of the objective of promoting cooperative learning among students' as stipulated in the mathematics curriculum. The results point to the idea that it might not be easy to fulfil these policy demands in the short term but may be feasible in the long term. The analysis of the students' interviews revealed that almost all the students acknowledged the importance of group work in providing new ideas and methods of solving problems. However, it was interesting to note that, despite this knowledge a number of these students were not much enthuse in working together as they think it will affect them during their final examinations since they do individual work during these examinations. This calls for a second look at the competitive nature of the Ghanaian school curriculum and the need for sensitization workshops for students' on the importance of group work in developing conceptual understanding of mathematical concepts is long overdue.

Finally, several issues emerged from this study that shows certain direction for further research and development. Considering the fact that the present study was limited to only one district in the country, conducting a similar study in other districts will provide a meaningful and holistic picture of the situation. Another area that could be investigated in detail is the impact of feedback from students on their colleagues' students learning experience and willingness to play an active role in the teaching-learning process.

10.7 Final Note

In closing, this research has contributed to the field of mathematics education especially in the Ghanaian context, and has provided some useful insights for teachers and other stakeholders in the educational sector. The findings are an eye-opener for both teachers and policy makers since, despite teachers' knowledge of the new curriculum guidelines, they have not been fully conceptualised in the classroom situation. This calls for education authorities to organise in-service training courses for teachers on the implementation of the new curriculum and, likewise, sensitisation workshops and guidance sessions for students on the importance of group work as a tool for promoting effective learning.

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Appendices

0.

Appendix A – Teachers' Pilot Questionnaire

Anglia Ruskin University
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Chelmsford Campus
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T: 0845 271 3333
Int: +44 (0)1245 493131
www.anglia.ac.uk

Dear Fellow Mathematics Educator,

I am a research student at the faculty of education at Anglia Ruskin University in the United Kingdom. I am conducting a research to investigate into the teaching and learning of mathematics in Ghanaian junior high schools. The purpose of the research is to explore into how mathematics is taught in Ghana.

I would like to invite you to take part in this first stage of the study which involves the development of the research instrument (questionnaire). I would appreciate if you could provide a pen portrait of your classroom practices by providing objective response which will help in developing the questionnaire for the study.

The information provided will be treated as confidential, and will only be used for the above purpose indicated above.

Thanks for your anticipated cooperation.

Yours Sincerely,

Ernest Ampadu
(Researcher)

1. School Location Urban ☐ Semi-Urban ☐ Rural ☐

2. Lesson Outline (Provide an outline of your mathematics lessons from introduction to conclusion).

   I. ....
   II. ....
   III. ....
   IV. ....
   V. ....
   VI. ....
   VII. ....
   VIII. ....

3. a) How do you normally start your mathematics lessons?...

....

....

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....

....

....

   b) Why do you normally start your mathematics lessons the way you have described in 1 (a)?

....

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....

4. What are your main priorities when teaching your students?

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5. a) What teaching method (s) do you normally use in your lessons?

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b) Why do you use this/these methods?

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6. Are there any factors that prevent you from teaching in the ways that you would like to?

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....
....

7. How do your students learn during mathematics lessons?

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....

8. What reading materials (textbooks, pamphlets etc.) do you normally use during your lessons?

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....
....
....

9. Approximately what proportion of the instructional time do you devote to the following activities?

   a) Whole class activities...

   b) Group activities..

   c) Individual student's activities...

10. How do you rate your students' interest in mathematics as compared to other subjects and why is it so?

    ....
    ....
    ....
    ....
    ....
    ....

11. What measures do you think you can put in place to help your students' to develop interest for mathematics?

    ....
    ....
    ....
    ....
    ....

12. In general describe how you teach mathematics.

....
....
....

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Appendix B: Students' Pilot Questionnaire

Dear Student,

Would you consider taking part in some research?

I am planning to do some research into how mathematics is taught and learnt in schools and would like to invite you to take part in the study.

I would like to invite you to take part in this first stage of the study which will involve the development of the research instrument (questionnaire) by answering the following questions. Your responses will be treated as confidential and will be used only for the above purpose.

Yours sincerely,

Ernest Ampadu

(Researcher)

Name of School:..

Class: JHS 1 ☐ JHS 2 ☐ JHS 3 ☐

Age...

1. To what extent do you like mathematics?

☐ ☐ ☐

Very much Some How Not at all

2. How often do you learn mathematics at home?

   Everyday ☐ Once a Week ☐ Sometimes ☐ Not at all ☐

3. Does your school have mathematics textbooks? Yes ☐ No ☐

4. How often does your teacher use the mathematics text books when teaching?

   Always ☐ Sometimes ☐ Not at all ☐

5. a) How often does your teacher ask you questions before starting a lesson?

   Always ☐ Sometimes ☐ Not at all ☐

   b) Are the questions that your teacher asks based on previous lessons or what you know already?

   Always ☐ Sometimes ☐ Not at all ☐

6. a) How often do you listen while your teacher explains?

   Always ☐ Sometimes ☐ Not at all ☐

   b) How often does your teacher tell you what to do during lessons?

   Always ☐ Sometimes ☐ Not at all ☐

   b) How often does your teacher ask you to work in groups?

   Always ☐ Sometimes ☐ Not at all ☐

   c) How often does your teacher ask you to work individually?

   Always ☐ Sometimes ☐ Not at all ☐

7. Which of the ways of working mathematics do you think helps you to understand mathematics?

   Working in Groups ☐ Individual working ☐ Both ☐

8. What problems do you face when learning mathematics?

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9. What do you think you can do to improve your interest in mathematics?

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10. What do you think that your teacher can do to help improve your learning of mathematics?

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Appendix C: Teachers' Final Questionnaire

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January 2010

Dear Fellow Mathematics Educator,

I am a research student at the Faculty of Education at Anglia Ruskin University in the United Kingdom. I am conducting a research to investigate into the teaching and learning of mathematics in Ghanaian junior high schools in the Central Region of Ghana. The purpose of the research is to explore how mathematics is taught in Ghana.

I would like to invite you to take part in this study by completing this questionnaire. The information provided will be treated as anonymous, confidential, and will only be used for the above purpose indicated and the name of your school will not be included in the final report. Please, see the attached participant information letter for more information.

Thanks for your anticipated cooperation.

Yours Sincerely,

Ernest Ampadu
(Researcher)

MATHEMATICS TEACHING QUESTIONNAIRE FOR TEACHERS'

This questionnaire is divided into three sections. The first section is for eliciting information about and your school. The second section is about your teaching priorities and teaching methods. The last section, section C is about your class room practices. Please, fill the questionnaire as truthfully as you can.

Instruction: ***Write or tick (√) the appropriate response to each item.***

SECTION A

BACKGROUND INFORMATION ABOUT YOU AND THE SCHOOL

1. (a) Name of School:……………………………………………………
2. (b) School Location Urban ☐ Rural ☐
3. Which class (s) do you teach? JHS 1 ☐ JHS 2 ☐ JHS 3 ☐
4. Gender: Male ☐ Female ☐
5. How old are you?

Age	**Tick**
Below 20 years	
21-25 years	
26-30 years	
31-35 years	
36- 40 years	
41-45 years	
46-50 years	
51 years and above	

6. What is your Professional Qualification?

Qualification	**Tick**
Teacher's Certificate 'A'	
Diploma (Education)	
Degree (B.Ed)	
Untrained Teacher	
Other Specify:……………………………………………………..	

7. a) Did you do mathematics at your diploma/undergraduate level?

Yes ☐ No ☐

b) If **Yes** to 6 (a), was mathematics your major or minor subject?

Major ☐ Minor ☐ Core Subject ☐

8. a) Did you opt for the teaching of mathematics in your school?

Yes ☐ No ☐

b) If **No**, please state the reason why you have taken to the teaching of mathematics?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

SECTION B

TEACHERS' TEACHING PRIORITIES AND METHODS

1. a) What are your main priorities when teaching mathematics to your class

(**Put them in order of importance, 1 being most important)?**

Priorities	**Rank**
To prepare students pass their Examination	
To help students to understand mathematics	
To help students appreciate the importance of mathematics	
To motivate students to have interest and positive attitude toward mathematics	
To be able to finish the syllabus	
Others……………………………………………………………	

b) Why do you consider priority ranked **ONE** as being most important?

………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

2. a) How often do you use the following teaching methods in your mathematics class?

Teaching Method	**Often**	**Sometimes**	**Never**
Lecture Method			
Activity Method			
Demonstration Method			
Group Work (among students)			
Discovery method			
Others (**Specify)………………………**			

b) Why do you use the method(s) mentioned above?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………………………………………………………………………………...

SECTION C

TEACHERS' PERCEPTION OF THEIR TEACHING PRACTICES

Complete the statements below of how you perceive your own classroom practices.

Tick in the appropriate column for your response to the following statements (Note: SA=Strongly Agree, A=Agree D= Disagree SD= Strongly Disagree).

NO	Statements	SA	A	D	SD
1	I start each mathematics topic by reviewing students' related prior knowledge.				
2	I teach each topic from the beginning, assuming they know nothing.				
3	I teach all the topics in the syllabus.				
4	I go through a variety of methods for solving each question.				
5	I use diverse approach when teaching a particular topic in mathematics.				
6	I draw links between topics and move back and forth between topics				
7	I use the national curriculum recommended teaching method for teaching mathematics.				
8	My students listen and copy notes while I explain.				
9	I ask students to complete easy tasks before attempting difficult ones				
10	I tell students which question to do during lessons.				
11	I explain things carefully to my students to help them avoid mistakes.				
12	I give students the procedures they need to follow when solving problems.				
13	I encourage my students to work on their own.				
14	I encourage students to use the methods I teach them.				
15	I go through one particular method for doing each mathematics question.				
16	I ask students to work in pairs or small group.				
17	I advise students to compare different methods for doing questions.				
18	I encourage students to develop their own method of solving problems.				
19	I encourage students to ask questions during mathematics lessons.				
20	I encourage students to set their own questions and try to solve them.				
21	I evaluate my students understanding through class exercises.				
22	I use the (GES) prescribed textbook for mathematics in my lessons.				
23	I use other textbooks and pamphlets for my lessons				
24	I give my students home work after each topic or lesson				

25	I always give feedback to my students on their class work, home work and class tests.				

Will you like to take part in the next stage of the research which involves classroom observation and interview? YES NO

Thank you for participating in this Survey!

Appendix D: Students' Final Questionnaire

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January 2010

Dear Student,

Would you consider taking part in some research?

I am conducting a research to investigate into the teaching and learning of mathematics in Ghanaian junior high schools. The purpose of the research is to explore how mathematics is taught in Ghana. I would like to invite you to take part in this research by completing this questionnaire. Your responses will be treated as confidential and will be used only for the above purpose.

Thanks for your anticipated cooperation.

Yours sincerely,

Ernest Ampadu

(Researcher)

MATHEMATICS TEACHING QUESTIONNAIRE FOR STUDENTS'

This questionnaire is divided into three sections. The first section is about your background information about you and your school. The second section is about your learning experiences, and the last section is about your perception of your teachers' teaching practices.

SECTION A

BACKGROUND INFORMATION

1. Name of School……………………………………………………………
2. What is your class? JHS 1 ☐ JHS 2 ☐ JHS 3 ☐
3. (a) How old are you (in complete years)?...

   (b) Gender Male ☐ Female ☐

4. Which of the following subjects do you like best?

Subject	Tick (tick only one)
Mathematics	
Science	
English	
Ghanaian Language	
ICT	
Others……………………….	

5. a) Do you intend to continue with your education after JHS?

   Yes ☐ Not Sure ☐ No ☐

   b) If yes to 4 (a) what programme do you want to do at the Senior High School (SHS) level?

Programme	**Tick**
Science	
Business Studies	
Agricultural Science	
General Arts	
Home Economics	
Technical	
Visual Arts	

6. What subjects would you like to read at the Senior High School level?

....

7 How often do you learn mathematics at home?

Everyday ☐ Twice a week ☐ Trice a week ☐

Four or more times a week ☐

SECTION B

LEARNING EXPERIENCES

Complete the statements below of how you perceive your learning experiences. Tick in the appropriate column for your response to the following statements (Note: SA=Strongly Agree, A=Agree D= Disagree SD= Strongly Disagree).

No.	Statement	SA	A	D	SD
1	I listen while the teacher explains				
2	I copy down the method from the board or textbook				
3	I only do questions I am told to do				
4	I work on my own				
5	I do easy problems first to increase my confidence				
6	I practice the same method repeatedly on my question				
7	I discuss my ideas in a group or with a partner				
8	I memorize rules and properties				
9	I make my own questions and methods				
10	I ask the teacher question when ever I do not understand				
11	I am silent when ever the teacher asks a question.				
12	I look for different ways of doing the question				

SECTION C

STUDENTS' PERCEPTION OF THEIR TEACHER'S TEACING PRACTICES

Complete the statements below of how you perceived your teachers teaching experiences. Tick in the appropriate column for your response to the following statements (Note: SA=Strongly Agree, A=Agree D= Disagree SD= Strongly Disagree).

NO	Statement	SA	A	D	SD
1	Our teacher asks us to work through practice exercise				
2	The teacher expects us to work on our own asking a colleague from time to time.				
3	The teacher shows us which method to use and then ask as to use it.				
4	The teacher tries to prevent us from making mistakes by explaining things carefully first.				
5	The teacher expects us to follow the textbook closely.				
6	The teacher tell us which questions to do				
7	The teacher expects us to learn through discussing our ideas.				
8	The teacher asks us to work in pairs or small groups				
9	The teacher lets us invent and use our own methods				
10	The teacher encourages us to make and discuss mistakes				
11	The teacher asks us to compare different methods for doing questions.				
12	Our teacher asks us to work through practice exercise.				
13	The teacher expects us to work on our own asking a colleague from time to time.				
14	The teacher shows us which method to use and then ask as to use it.				
15	We normally use our textbooks during mathematics lessons.				
16	Our mathematics teacher always gives us home work after each lesson.				
17	Our mathematics teacher normally gives us class exercises after each topic.				
18	Our mathematics teacher normally marks our exercises and discusses our results with us.				

Will you like to take part in the next stage of the research which involves classroom observation and interview? YES NO ☐ ☐

Thanks for Participating in this Survey

Appendix E: Observation Protocol

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AN INVESTIGATION INTO THE TEACHING AND LEARNING OF MATHEMATICS IN GHANAIAN JUNIOR HIGH SCHOOLS

OBSERVATION PROTOCOL

JANUARY 2010

Classroom Observation Protocol

BACKGROUND INFORMATION

Name of teacher:………………………………………………………………………………

Name of School:………………………………………………………………………………

Topic:………………………………………. Date:……………………………………

Class:……………………………………… Number of Students:…………………..

Date of Observation:…………………………………………………………………………

Lesson Starts:……………………………… Lesson Ends:……………………………

LESSON DESIGN		**Description of Events**
Students Prior knowledge was reviewed	Yes No	
The teaching strategy used was?	Lecture Method Activity Method Demonstration Method Group Work Discovery Method	
The lesson was designed to develop students understanding of a particular concept.	Yes No	

LESSON DESIGN		Description of Events
The lesson focus and direction was determined by ideas from students	Yes To some extent Never occurred	
The lesson engaged students	Yes To some extent Never occurred	
The teacher used the prescribed textbook for the lesson.	Yes Sometimes Never occurred	
STUNDENTS PARTICIPATION		
Students played active role in the teaching- learning process	Yes Sometimes Never occurred	
Students were allowed to discuss their ideas with their colleagues.	Yes Sometimes Never occurred	
Students were given the chance to find ways of solving problems on their own.	Yes Sometimes Never occurred	

LESSON DESIGN		Description of Events
Students were encouraged to use variety of methods in solving problems.	Yes Sometimes Never occurred	
Students were encouraged to make predictions and discuss their mistakes	Yes Sometimes Never occurred	
Students were given the chance to ask questions.	Yes Sometimes Never occurred	
Students questions were given the needed attention	Yes Sometimes Never occurred	
Students were given the chance to perform investigations in developing their own understanding.	Yes Sometimes Never occurred	
There was a high proportion of students talk.	Yes Sometimes Never occurred	

TEACHER/STUDENT RELATIONSHIP		**Description of Events**
Students participation was encouraged and valued	Yes Sometimes Never occurred	
The teacher acted as a facilitator in the teaching learning process	Yes Sometimes Never occurred	
The teacher took his/her time to explain things to students	Yes Sometimes Never occurred	
There was equal respect among the teacher and the students.	Yes Sometimes Never occurred	

Appendix F: Teachers' Interview Guide

Teachers' Interview Guide

Name of Teacher:…………………………………………………………………..

School Name:……………………………………………………………………….

Class JHS 1 ☐ **JHS 2** ☐ **JHS 3** ☐

Gender: Male ☐ **Female** ☐

Date of Interview:…………………………………………………………………

Interview start time:…...

Interview Duration:……………………………………………………………….

1. a) How long have you been teaching?

   b) How long have you been teaching mathematics?
2. How do you normally begin your lesson?
3. How would you define "teaching well" For instance under what circumstances would you be assured you have taught well?
4. What are your main priorities when teaching your students? Why?
5. What method (s) do you normally use in your teaching?
6. Why do you normally use this/these method (s)?
7. Do you normally use a variety of the methods mentioned in question 4? Why?
8. How do you promote students participation in your lessons?
9. a) How do you think is/are the best way (s) of teaching mathematics?

   b) What do you think is/are the best way (s) of learning mathematics?
10. In general what are your views on mathematics teaching and learning?

Appendix G: Students’ Interview Guide

Students’ Interview Guide

Name of student:…………………………………… Age ………………….

School Name:………………………………………………………………

Class JHS 1 ☐ JHS 2 ☐ JHS 3 ☐

Date of Interview:…………………………………………………………….

Interview start time:…..

Interview Duration:………………………………………………………

1. How often do you learn mathematics and why?
2. How often do you answer questions during mathematics lessons?
3. a) If you know the answer to a question, would you volunteer to answer?

   b) What happens when you give wrong answer?

   c) How do you feel when you give a wrong answer?
4. What does it take for a student to be successful in mathematics?
5. What do you expect from a good mathematics teacher?
6. How does your teacher promote students participation in the teaching-learning process?
7. What kind of teaching methods does your mathematics teacher normally use?
8. Do you think the teaching you experienced is the type of teaching that you believe should be used at the JHS level? Why?
9. Do you normally work alone or with your colleagues during mathematics lessons?
10. Which of these ways of learning do you prefer most? Why?

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Appendix H: Teachers' Consent Form

Teachers' Consent Form

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High Schools.

Name of Researcher: Ernest Ampadu

Participant Identification Number for this Project:……………………………………..

I confirm that I have read and understand the participant information sheet for the above mentioned research project. I understand my participation is voluntary and that I am free withdraw at any time without any reason. I also understand, my responses will be treated as confidential (anonymised). I permit members of the research team to have access to my anonymised responses. I hereby agree to take part in the above mentioned research project.

…………………………	……………………	……………..
(Name of participant)	(Date)	(Signature)
Ernest Ampadu………	………………………	…………..
(Name of Researcher)	(Date)	(Signature)

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High Schools.

I WISH TO WITHDRAW FROM THIS STUDY

Signed: ___________________________________ Date: _____________________

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Appendix I: Students' Consent Form

Students' Consent Form

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High Schools.

Name of Researcher: Ernest Ampadu

Participant Identification Number for this Project:……………………………………..

I confirm that I have read and understand the participant information sheet for the above mentioned research project. I understand my participation is voluntary and that I am free withdraw at any time without any reason. I also understand, my responses will be treated as confidential (anonymised). I permit members of the research team to have access to my anonymised responses. I hereby agree to take part in the above mentioned research project.

…………………………	……………………	………………………
(Name of participant)	(Date)	(Signature)
……………………………	………………………	…………………….
(Name of Witness)	(Date)	(Signature)
Ernest Ampadu………	………………………	…………………….
(Name of Researcher)	(Date)	(Signature)

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High Schools.

I WISH TO WITHDRAW FROM THIS STUDY

Signed: ___________________________________ Date: _____________________

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Cambridge & Chelmsford

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Appendix J: Teachers' Information Sheet

Teachers' Information Sheet

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High School.

Name of Researcher: Ernest Ampadu

Dear Sir/Madam,

This is an invitation to participate in the above mentioned research project. Before you decide it is important for your to take some time to read the following information to understand why the research is been done and what it will involve. The purpose of this research is to explore the teaching and learning strategies adopted in mathematics classrooms and how this impact on students learning and understanding. The study also wishes to explore some of the factors affecting mathematics teaching and learning in Junior High Schools. Participation in this study is voluntary. Refusal to take part will involve no penalty. If you decide to take part, you will be given a consent form to complete and you are still free to withdraw at any time without giving any reason. If you choose to be included, you will be asked to complete a questionnaire with questions on your bio-data, teaching practices and experience, factors affecting your teaching and your attitude toward mathematics teaching. After this, some classes will be selected for classroom observation and face-to-face interviews. If your class is selected you will be observed during a mathematics lesson after which the researcher will conduct a 15-30 minutes interview that will be audio taped to ascertain your views on mathematics teaching and learning: factors that have affected or inhibited your choice of a specific teaching strategy and some of the factors which you think affect mathematics teaching and learning. It is not mandatory for all teachers to take part in the interview. Only teachers who volunteer to be interviewed will be interviewed. Apart from your time for completing the study questionnaire, interview and observation, I can foresee no risks for you.

Apart from your time for completing the study questionnaire, interview and observation, I can foresee no risks for you. Your participation will help to get information which will be useful to educational authorities and policy makers in providing resources for improving mathematics teaching and learning. You are assured that all the responses that you will give throughout your participation will be treated as highly confidential. Any information which may lead to identifying the schools and the individual teachers will not be included in the final write up. If you have any questions do not hesitate to ask. If you would like to participate, please, ask for a consent form. If you are interested in the research findings I will be happy to provide a summary of the findings.

Thank you,
Ernest Ampadu (Researcher)
Researcher Contact (ernestampadu@yahoo.ca, 0209262690)

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Appendix K: Students' Information Sheet

Students' Information Sheet

Title of Project: An Investigation into the Teaching and Learning of Mathematics in Ghanaian Junior High Schools.

Name of Researcher: Ernest Ampadu

Dear Student,

Would you consider taking part in some research?
I am planning to do some research to investigate how mathematics is taught and learnt in schools and would like to invite you to take part in the study. But before you decide to or not to take part or not, it is important for your to take some time to read the following information to understand why the research is been done and what it will involve.

What is the Purpose of the Study?
The purpose of this research is to understand how mathematics is taught and learnt in schools. The study also wishes to examine some of the factors affecting mathematics teaching and learning in Junior High Schools.

Who is asked to take part and why have I been chosen?
All junior high school students are invited to take part in the study. You have been chosen to take part because your school have been selected for the study.

Do I have to take part?
No. It is up to you to decide whether or not to take part. Refusal to take part will involve no penalty. If you decide to take part you will be given a consent form to complete and you are still free to withdraw at any time without giving any reason.

What will happen if I take part?
If you choose to be included, you will be asked to complete a questionnaire. After this, some classes will be selected for classroom

observation and interviews. If your class is selected you will be observed during a mathematics lesson after which some of you will be interviewed. Only students who would like to be interviewed will be interviewed.

What are the possible benefits of taking part?
After completing the study I will provide you with a summary of the results if you wish to. The information that you provide will also help educational authorities in improving the quality of teaching and learning of mathematics in our schools.

What are the possible disadvantages and risks of taking part?
Apart from your time for completing the study questionnaire, interview and observation, I do not think there is any risk for you when you take part.

Confidentiality – What will happen to the information I provide?
When I write up the study everyone's name and the names of schools will be changed so that no one can be identified. Also any information which may lead to identifying the schools or the students will be removed from the final write up. You will be welcome to choose your own name to be used during the study.

If you have any questions do not hesitate to ask. If you would like to participate, please, ask for a consent form.

Thank you,

Ernest Ampadu (Researcher)
Researcher Contact (ernestampadu@yahoo.ca, 0209262690)

Appendix L: Ethics Approval

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Ernest Ampadu
123 Fortinbras Way
Chelmsford
CM2 9UL

01 September 2008

Dear Ernest

Project Title: *An investigation into the teaching and learning of mathematics in Ghanian Junior High Schools*

Principal Investigator: *Ernest Ampadu*

Thank you for supplying revisions to your ethics application in consultation with your sponsor Professor Bronwen Walter.

The Chair of UREC, acting on behalf of the Committee, has now agreed to grant ethics approval to your research. Approval has been granted for a period of three years from 26th August 2008

Ethics approval is also subject to random monitoring by the Committee.

Please be advised that, if your research has not been completed within three years, you will need to apply to the University Research Ethics Committee for an extension of ethics approval. Similarly, if your research should change significantly in <u>any</u> respect, or if risk of harm or breach of confidentiality becomes likely, you will be obliged to submit a new application.

Good luck with your research.

Yours sincerely

Beverley Pascoe
Secretary, University Research Ethics Committee

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E: b.pascoe@anglia.ac.uk

cc Theodora Papatheodorou

INVESTOR IN PEOPLE

POSITIVE ABOUT DISABLED PEOPLE

Appendix M: Introductory Letter

GHANA EDUCATION SERVICE

In case of reply the number and date of this letter should be quoted

REPUBLIC OF GHANA

METROPOLITAN EDUCATION OFFICE
P. O. BOX 164
CAPE COAST

Tel: 042-32514/33405
Fax: 042-32199

12th January, 2010

My Ref. No. GES/MD/EP.1/VOL.2/121

Your Ref. No………………

HEADTEACHERS CONCERNED
CAPE COAST METROPOLIS

<u>PERMISSION TO CONDUCT RESEARCH IN SOME SELECTED SCHOOLS IN CAPE COAST METROPOLIS</u>

I introduce to you Mr. Ernest Ampadu a student of Anglia Ruskin University, United Kingdom. He is conducting a research into the teaching and learning of Mathematics in the Cape Coast Metropolis.

Permission has been granted him to do the investigation is some selected JHS schools of which yours is one.

Please, give him the needed assistance.

Thanks for your usual co-operation.

SIMEON OBOTAN LARBI
METRO DIRECTOR OF EDUCATION
CAPE COAST