Science and Mathematics Education Centre

Productive Pedagogies for Reforming Secondary School Mathematics Classroom Practice in Nigeria

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DECLARATION

To the best of my knowledge and belief, this thesis contains no materials previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

24/2/2014

DEDICATION

This thesis is dedicated to my beloved sister Jummai Bature who died 1st December 2013 at the eve of its completion. Sister, you spared no kobo to lay the foundation of our Lives. You will always be remembered when this thesis is read by all. Most of all this thesis is dedicated to God the Father, the Son and the Holy Spirit for the inspiration to put the content of this work into writing.

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ABSTRACT

This study aimed to investigate the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. Specifically, the researcher considered the scaffolding needed by the participating teachers to implement the framework, the implementation process, the challenges encountered, and the perception of the students during the classroom teaching. The researcher adopted a qualitative case study approach to investigate four participating teachers' classroom instruction for a period of fifteen weeks. Data was collected through planning and reflection meetings and casual interviews with the participating teachers, and focus group and casual interviews with selected students. Grounded theory approach was adopted to analyse the data collected.

The findings of the study suggest that the participating teachers made effort to adapt their teaching according to the principles of Productive Pedagogies. This was demonstrated by a clear shift from the traditional classroom instruction that constructed students as mere recipients of knowledge to a much more student-centred teaching. The findings also suggest that the teachers were able to create a supportive classrooms climate to allow students to construct their knowledge through the resulting pedagogies. The reflections of participating teachers and the students suggest that Productive Pedagogies could be an effective tool for improving teacher-student relationships that had bedevilled the mathematics classrooms in Nigeria. This was demonstrated through the friendly and inclusive classroom climate created by the teachers and enjoyed by their students. The findings of the study demonstrate that with sufficient and sustained support for the teachers during classroom teaching, Productive Pedagogies could be a useful tool to help change classroom instruction.

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CHAPTER 1

INTRODUCTION

1.1: Background

It is widely believed in Nigeria that mathematics is an important subject. This is evidenced by the emphases placed on its learning by teachers, parents and schools. Mathematics in Nigeria is a compulsory subject for admission into universities, colleges of education and polytechnics. In every society, mathematics is seen as a backbone of science and technology because of its indispensability to many fields of human endeavours. Mathematics plays an important role in our daily lives; hence, one can avoid it at a cost.

However, students' achievement in this subject in Nigeria over the years has not been encouraging at the primary, secondary and at tertiary levels. Bature and Bature (2005) summarized this by saying that the state of students' achievement in mathematics in the country had left much to be desired. This concern is shared by the West African Examination Council (WAEC) and National Examination Council (NECO).

According to the Senior School Certificate Examination (SSCE) results released each year, the percentage of students' passes at credit level is very low. For example, the SSCE results for 2010, 2011 and 2012 for Nigeria, as published by the WAEC, were 30.91%, 23.71% and 38.81%, respectively, demonstrating the low general achievement in mathematics (Dike & Osu, 2012). Similarly, in the year 2010 when WAEC and NECO released their May/June/July SSCE results, the outcomes of the two examinations were roundly condemned. The general remarks from different stakeholders across the country on the less than 25% credit pass for WAEC and NECO in five subjects, including English and mathematics, left no one in doubt that the poor performance of candidates in the two external examinations was a national concern (Garba, 2012).

In Nigeria, this poor performance of students in mathematics had generated considerable debate as to who is responsible and what are the causes. Adedayo (2001) and Bature and Bature (2006) attributed the failure in mathematic to a mathematics phobia by some students, particularly among girls. Bature and Bature (2005) suggested that the cause of the poor performance could be the negative attitude of students, parents and teachers towards mathematics and the teaching of mathematics. Rollnick (2000) and Bature (2006) saw it in terms of culture, parental socio-economic status, and lack of parental encouragement. Bature and Igweh (2010) believed that one reason for the poor performance is the abstract nature of mathematics and its language. Others viewed it in terms of teachers' lack of competence in teaching; the low teachers' background knowledge in mathematics and poor quality of mathematics teachers employed to teach mathematics in our secondary schools.

Similarly, Johnson (2004) and Nwagbo (1999) suggested that most mathematics teachers in Nigerian schools were not taught mathematics while in school using inquiry and collaborative instructional strategies. Since they did not have these opportunities, they find it difficult implementing them in their classrooms. Osuafor (1999) also argued that mathematics teachers in Nigeria have limited knowledge on how to effectively utilize innovative mathematics instructional strategies such as problem solving, projects, and concept mapping. This raised questions about the quality of mathematics teacher programs in Nigeria and how well mathematics teachers are prepared to handle mathematics instruction in their classrooms in order to produce the desired student outcomes.

The National Objectives of Mathematics in the National Policy on Education in (Federal Government of Nigeria (FGN), 2008) Nigeria highlights the necessity of mathematics teachers to help their students to acquire needed mathematical knowledge that will enable them to function effectively in the information age. Mathematics teachers need to cultivate in students the understanding and the ability of applying mathematical concepts and procedures necessary to thrive in an ever-changing technological world (Federal Government of Nigeria (FGN), 2008). Abanihe, Ifeoma, John and Tandi (2010) were of the view that if mathematics teachers hoped to achieve quality classroom teaching, there is the need to develop in students the essential elements of problem solving, communication, and reasoning.

Similarly, the National Objectives of Education in Nigeria through the National Policy on Education emphasises the role of teachers in quality (mathematics) teaching (FGN, 2008). This is because mathematics teachers have a significant influence on students' performance in mathematics (Barton & Barton, 2003; Bature & Bature, 2005; Cocking & Chipman, 1988; Durosaro, 1995; Sule, 1995). Therefore, improving quality mathematics teaching for the attainment of the above objectives is essential for national development. If Nigeria as a country wishes to join the top industrialized countries in the world, teacher development, especially at the primary and secondary schools levels should be made a key factor in improving students' performance (Abanihe, et al., 2010).

Teachers' attitude to the teaching of mathematics also plays a significant role in shaping students' attitudes towards mathematics learning. Ogunniyi (2009) was of the view that students' positive attitudes towards mathematics could be enhanced by the following teacher-related factors: mathematics teachers' enthusiasm, resourcefulness, helpful behaviour, knowledge of the subject-matter, and the ability to make mathematics teaching interesting. This suggest that, a teacher is a significant factor in any educational system and no matter what amount of resources a nation puts into its education system, without proper preparation and motivation of teachers, there could be no positive impact on students' learning.

The importance of teachers at all levels of education in Nigeria is reflected in the National Policy on Education (FGN, 2004, Hattie, 2009). It declares that no educational system can rise above the quality of its teachers. This is supported by the view of Eso (1998) who posited that competence, ability, resourcefulness, and ingenuity to efficiently utilize the appropriate language, methodology and available instructional strategies are key basic attributes of an effective teacher. Abimbade (1999) was of the view that teachers are said to be effective when their teaching leads to students' learning. Nothing has been taught until it has been learnt and this happens when the teacher succeeds in causing a change in understanding and behaviour in the students.

Rasmussen and Marrongelle (2006) was also of the view that quality mathematics teachers are teachers that are perceived to be knowledgeable in their subject matter, very organized and prepared for their classroom instruction and are enthusiastic in their approach to mathematics teaching in the classroom. Bajah (1999) believed that quality mathematics teachers are those that have the ability to stimulate students' interest. Bajah went further to suggest that the important characteristics of quality teachers include course management and interpersonal traits such as helpfulness, openness, and friendliness. This suggests that to some extent the characteristics and behaviours of quality mathematics teachers contribute to the learning environment of their students, which in turn will have an effect on students' learning outcomes.

With reference to these views, achieving quality teaching implies that the content of the secondary school mathematics curriculum and the methodology used in the preparation of mathematics students in Nigeria must fit into the National Objectives of Mathematics Education (Abanihe et al., 2010). Since the mathematics curriculum in Nigerian secondary schools is designed with the constructivist view to classroom instruction, mathematics teachers in Nigeria have to strive to apply this approach in their mathematics teaching. The Nigerian mathematics teachers must also strive to make mathematics instruction more practical, inquiry based, collaborative and to allow students to be engaged in problem solving activities (Adiku, 2008).

However, most commonly adopted strategies for mathematics classroom instruction in Nigerian classrooms are in line with what can be called traditional teacher-centred approach. This traditional approach permits the teacher to be in control of all the activities in the class (Abanihe et al., 2010). Similarly, Kaka (2007) was of the view that this traditional classroom instruction in Nigerian mathematics classrooms remains unquestioned. This is in stark contrast to the National Objectives of mathematics as indicated in the National Policy on Education that mathematics teachers should adopt the enquiry and the constructivist student-centred approaches to classroom instruction (FGN, 2004).

Research results indicate that most mathematics teachers in Nigeria also monopolize communication during classroom teaching, dominate classroom discussion, and maintain a basic structure in mathematics classrooms that heavily relies on the teacher-centred approach (Azuka: 2006; Kaka, 2007; Odilli: 2006). In this approach, mathematics teachers dominate classroom talk, while students' responsibility is to listen carefully and copy examples given on the chalkboard. Similarly, this traditional approach does not give students opportunity to contribute to classroom discussions (Emaikwu, 2012). There is a need, therefore, for mathematics teachers to encourage collaboration, discourse and cooperation in the classroom. If mathematics teachers hope to achieve quality classroom teaching, they should foster interactions with students and between students to a greater extent.

To develop quality classroom instruction, the School Reform Longitudinal Study (SRLS) research team of the University of Queensland were of the view that classroom instruction should be build based on students' engagements and contribution to classroom instruction. That will contribute to the enhancement of the academic and social performance of student, and will lead to improved outcomes for all students. This study attempted to introduce Productive Pedagogies framework into the Nigerian mathematics classroom towards achieving quality classroom teaching.

1.2: Productive Pedagogies

When the word 'pedagogy' is used, it connotes a range of approaches, strategies, competencies, skills, and tactics of organising ideas that teachers apply to bring about quality classroom teaching. Mathematics educators in more than six decades had made concerted effort in addressing the philosophical and epistemological perspectives to mathematics and to mathematics teaching. For example notable researchers like Ernest (1991), Freudental (1978) and Skemp (1976) thought of mathematics in a fallibilistic terms. Davis, Maher and Noddings (1990) and Glasersfeld (1987) thought of mathematics learning in a constructive process. Lave and Wenger, (1991) thought of mathematics teaching and learning through situate knowledge relative to communities of practice. And finally, the debate on the commensurability of constructivist and sociocultural learning theories suggested by Lerman (1996) and Steffe and Thompson, (2001) also suggested the philosophical and the epistemological development of mathematics teaching and learning.

Looking back over these years one might infer that constructivism and sociocultural theories that have been highly influential in addressing the teaching of mathematics as keys to the development of strategies for a drastic changes to mathematics classrooms (Jaworski, 2006). This had led to the maturity of the theoretical considerations of mathematics education discipline in the developed and the developing countries. However, the position of mathematics teaching remains theoretically anomalous and underdeveloped (Jaworski, 2006) particularly in Nigerian mathematics classrooms where the traditional teacher-centred teaching still prevail (Azuka: 2006; Kaka, 2007; Odilli: 2006).

Generally, several frameworks exist in literature that support the development of a variety of teaching techniques based on different theoretical underpinnings (Atweh, 2007). For example, first, the use of multi-tiered scale by teachers to express the level of expertise required to achieve measurable student outcome during classroom teaching (Anderson & Krathwohl, 2001) commonly referred to as *Bloom Taxonomy*

(Bloom, 1956). Second, the *Howard Gardner's theory of Multiple Intelligences* which believed that "*we are not all the same, we do not all have the same kinds of minds, and education works most effectively for most individuals if...human differences are taken seriously"* (Gardner, 1995, p.208). Third, the *Debono's thinking Hats*; which provides a framework to help people think clearly and thoroughly by directing their thinking attention in one direction at a time (de Bono, 1991). And finally, the *Myer-Briggs Personality Types* which burthened on how a designed personality test can assist a person identify some significant personal preferences in thinking and learning (Briggs Myers, McCaulley, Quenk, & Hammer, 1998).

These different frameworks possess some characteristics that may be similar to one another. However, none of these frameworks and strategies contains prescriptive teaching tools for the teacher. According to Atweh (2007) these teaching techniques or what he called tools are "u*sed for reflection for teachers to critique their own pedagogy in order to designed alternative pedagogies" (p.98).* Similarly, Atweh when further to suggest that none of these framework or teaching techniques is content based. That is, they can be used in a variety of subject areas and at different levels of teaching. Atweh noted that the educational research base on which these tools or framework of teaching are built are perhaps limited and

> *Focus more on higher order thinking and intelligence, constructed under the individualistic models of learning…, they don't take into account the social dimension of learning…, While some of them might acknowledge individual differences in thinking style and preference to learning, they do not account for the effects of student background and their social context. (p.98)*

Similarly, there are several other teaching models or frameworks that have been developed by researchers and educators to specifically improve the teaching and learning of mathematics across countries. These models were not specifically for mathematics classroom teaching alone, but for general improvement of teaching across subjects. Prominent among them are the *"Rich Task"* where Piggott (2004) asserted that mathematics enrichment is not simply learning facts and demonstrating skills, it involves skills and knowledge acquisitions which could be precursors to, and also outcomes of a rich driven learning. And Ernest (2000) was of the view that mathematics enrichment represents an open and flexible approach to teaching mathematics which encourages experimentation and communication. There is also the *Critical Mathematics Education*, which is concerned with the social and political aspects of mathematics teaching and learning (Atweh, 2007; Skovsmose & Borba, 2004; Valero, 2009). *The Montessori Pedagogies* which is designed to help students progress at their own pace, rhythm and according to their individual capabilities (Montessori, 2003).

One framework developed recently in the state of Queensland in Australia, called Productive Pedagogies is an example of an attempt to integrate research findings on effective teaching from a variety of areas of research within education itself, and classroom practice. Specifically, Productive Pedagogies is the product of a longitudinal study on school reform undertaken in Queensland, Australia (Lingard, Ladwig, Mills, Bahr, Chant, Warry, Ailwood, Capeness, Christie, Gore, Hayes, & Luke, 2001).

The basic aim of the framework is the enhancement of quality classroom teaching. It rejects the emphasis on a credentialed society which defines quality in terms of students' outcomes demonstrated by standardized test of basic skills (Zyngier, 2005). It however, defines students outcomes in terms of a sustained and disciplined inquiry focused on powerful, important ideas and concepts which are connected with the students' experiences and the world around them (Atweh, 2014, Zyngier, 2005). This suggests that Productive Pedagogies framework is concerned with how to help students learn and how to enhance both their academic and social outcomes during classroom instruction.

The developers of Productive Pedagogies framework (Lingard et al. 2001) postulated four dimensions which described and characterised what could be termed quality teaching (Atweh, 2014). These includes; Intellectual Quality, Connectedness, Supportive Classroom Environment, and the Recognition of Difference. Each dimension was further elaborated by a number of elements constituting it (Lingard et al. 2001).

Intellectual Quality is an important dimension in achieving quality classroom teaching. Previous studies indicate that high Intellectual Quality classrooms help improve students' performance during classroom instruction (Boaler, 1997; Hayes, Mills, Christie, & Lingard, 2006). Connectedness attempts to make mathematics more relevant to students' life by connecting students' life experiences either at home or in the society with their lives in school (curriculum and content) or other school subjects. This attempt is with the view to make mathematics more 'relevant' and provide students with more meaningful life experiences (Atweh, 2007). The Supportive Classroom Environment dimension is needed to create and enabling learning environments involving support and engagement in order to foster high Intellectual Quality and Connectedness. Finally, on Recognition of Difference, Hayes et al. (2006) was of the view that teachers should give more emphasis to recognize the diversities that exist among students with different cultural backgrounds and beliefs during classroom instruction in order to provide an equitable outcomes for all students.

The Productive Pedagogies framework has become a focus of research and curriculum development efforts over the last decade in several projects around the world. In its efforts to improve achievement and interest in the study of mathematics and other subjects across all school levels, the Queensland State Government initiated the New Basic Project in 2001 (Department of Education, Training and Employment). The New Basics Projects provided new curriculum organisations, authentic assessment tasks, and a framework for designing teaching called the Productive Pedagogies (Tanko & Atweh, 2012). Similarly, Zingier (2005) indicated that the Productive Pedagogies framework has been adopted in many states and regions across Australia like in New South Wales, Tasmania, South Australia and Victoria. Other studies had also used Productive Pedagogies to prepare a series of professional development activities for in-service teachers (Gore, Griffiths & Ladwig, 2002).

There are several other research studies that have utilised the Productive Pedagogies framework in teacher education across the globe. For example, Alsharif and Atweh (2012) in Saudi Arabia modelled the Productive Pedagogies framework in pre-service teachers' education programs to develop their pedagogical practices during their field experience. Tanko and Atweh (2012) used the Productive Pedagogy framework to improve the teaching and learning of practical numeracy with adult learners in United Arab Emirate. Similarly, Productive Pedagogies framework had been used to introduce social justices' practices in classroom instruction (Bacon, 2012; Bartel, 2012; Tanko, 2012). Other studies used the Productive Pedagogies framework to increase students-teacher awareness of teaching pedagogies that could improve classroom engagement, participation, and to implement critical reflection among teachers and students (Aveling & Hatchell, 2007, 2000; Sorin & Klein, 2002; Wilson & Klein Zyngier 2005).

In this current study, the researcher adopted the Productive Pedagogies framework because on the following potentials.

First, the Productive Pedagogies framework is believed to providing opportunities for individual teachers to reflect on their own lessons, either at the planning stage or after the conduct of the classroom, using the four dimensions of the framework (Atweh, 2007). The teacher can ask herself/himself whether the lesson demonstrated high quality content in its presentation; whether the lesson provided enough support to students, or whether the increase of the recognition of differences, social and cultural groups in the classroom helped improved students learning and engagements.

Second, Productive Pedagogies framework is believed to have the potential of helping teachers' obtain or provide critical friends comments on each other classroom teaching. This allows both teacher and classroom observer to enter into substantive conversation about pedagogy. It has the potential to be used in group planning for the curriculum in the school for one level in one subject, or across levels and subjects.

Third, the researcher believed that the Productive Pedagogies framework can be used for the professional development of teachers and as a form of induction to both preservice and in-service teachers in the schools, which could be an effective means for giving feedback to teachers for commencing a conversation about promoting authentic and quality classroom teaching.

Fourth, the Queensland School Reform Longitudinal Study pointed certain conditions that make the research on Productive Pedagogies open to other social settings. First, they assertion that, each dimensions of Productive Pedagogies is readily defended in an ideal setting and in the context in which it was developed, however, depends on the prevailing circumstances surrounding the classroom in terms of classroom environments and other socio cultural forces makes the research on Productive Pedagogies open to further investigations particularly on other social cultural environments. Second, the four dimensions of Productive Pedagogies may be necessary and sufficient for students to perform well in school; there is however, no substantial evidence or research basis for believing that all the dimensions are equally required for success in all socio-cultural settings (Lingard at al. 2001). Third, different classroom activities may reflect some of these dimension more than others (Atweh, 2007) for example, some classes may demonstrate low level Intellectual Qualities, while others demonstrate high level of Intellectual Quality with the attempt to connect learning to students' life experiences.

Therefore, one may conclude by saying that, Productive Pedagogies may work in one environment and fail to work in other environments depending on the prevailing circumstances surrounding the environment. This informed the need for this research to investigate the process and the effect of introducing Productive Pedagogies into Nigerian secondary schools mathematics classroom.

1.3: Aims of the Study

This study aimed to investigates the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. Specifically this research investigates:

1. The scaffolding needed by participating teachers to implement the Productive Pedagogies framework;
2. The changes in the participating teachers classroom practice as a result of the implementation of the Productive Pedagogies framework
3. The participating teachers' reflections on the effect of Productive Pedagogies framework on their practice;
4. The perceptions of students on the effects of Productive Pedagogies framework on their engagement;
5. The challenges that participating teachers encountered while introducing Productive Pedagogies;

1.4: The Geographical Context of the Study

An understanding of the geo-political context in which a research is conducted is crucial to readers who are not conversant with the location of the research.

The name Nigeria (coined by Flora Shaw, the wife of Baron Lugard, a British colonial administrator, in the late 19th century) was taken from the Niger River running through the country. Nigeria became independent in 1960. Nigeria, officially the Federal Republic of Nigeria, is a federal constitutional republic comprising 36 states and its Federal Capital Territory, Abuja. The country is located in West Africa and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast in the south lies on the Gulf of Guinea on the Atlantic Ocean (Shaw & Jameson, 2002). The three largest and most influential ethnic groups in Nigeria are the Hausa, Igbo and Yoruba. Although, people speak their native languages, English is the official language in Nigerian schools and in most official and economic activities across the country (Isichei, 1997).

The people of Nigeria have an extensive history. Archaeological evidence shows that human habitation in Nigeria dates back to at least 9000 BC. The area around the Benue and Cross River is thought to be the original homeland of the Bantu migrants who spread across most of central and Southern Africa in waves between the first and second millennia BC. The Nock people of central Nigeria produced the earliest terracotta sculptures found in the country which was discovered between 500BC to 200AD in the present Jaba Local Government Area of Kaduna state (Isichei, 1997). Nigeria is the most populous country in Africa and the seventh most populous country in the world. It is a member of the Commonwealth of Nations.

Nigerian economy is classified as a mixed economy, emerging market, and has already reached middle income status according to the World Bank, with its abundant supply of natural resources, well-developed financial, legal, communications, transport sectors and stock exchange (the second largest in Africa) (Edoumiekumo & Opukri, 2013). Nigeria was ranked 31st in the world in terms of GDP in 2011. Although much has been made of its status as a major exporter of oil, Nigeria produces only about 2.7% of the world's supply. However, Nigeria is the 12th largest producer of petroleum in the world and the 8th largest exporter to other countries, especially the USA where it supplies 20% of USA oil consumption (Edoumiekumo & Opukri, 2013).

Though the petroleum sector is important to Nigeria, it remains in fact a small percentage of the country's overall diversified economy. For example, Achah and Morrissey (2005) were of the view that the largely subsistence agricultural sector in Nigeria has not kept up with the nations' rapid population growth. Nigeria that used to be one of the largest exporters of food in the world is today importing a large quantity of its food products from other countries. Achah and Morrissey (2005) also asserted that Agriculture used to be the principal foreign exchange earner of Nigeria. At one time, Nigeria was the world's largest exporter of groundnuts, cocoa, and palm oil and a significant producer of coconuts, citrus fruits, maize, pearl millet, cassava, yams and sugar cane. About 60% of Nigerians work in the agricultural sector, and Nigeria has vast areas of under-utilized rich productive land for farming.

Similarly, Nigeria has one of the fastest growing telecommunications markets in the world. Major emerging market operators like MTN, Etisalat, Zain and Globacom have based their largest and most profitable centres in the country (Achah & Morrissey, 2005). The government has recently begun expanding this infrastructure to space based communications. Nigeria has a space satellite which is monitored at the Nigerian National Space Research and Development Agency headquarters in Abuja. Nigeria has a highly developed financial services sector, with a mixture of local and international banks, and asset management companies. It also has brokerage houses, insurance companies and brokers, private equity funds and investment banks. And finally, Nigeria also has a wide array of under-exploited mineral resources which include natural gas, coal, bauxite, tantalite, gold, tin, iron ore, limestone, niobium, lead and zinc (Rodrik, 2001).

1.5: Literacy Levels in Nigeria

One of the major challenges facing Nigeria today is how to reform its education sector and train sufficient high quality manpower to develop the nation's economy. According to Dike (2009), much has been said about reforming the nation's falling standard of education and how to revive it; however, despite all these reform efforts, no appropriate action has been taken to solve the problem. One of the major problems facing the Nigerian education system is the overcrowded and chaotic nature of the nation's classrooms and the dwindling literacy rate especially among the school-going age children.

Literacy, according to Dike, is the ability of an individual to read and write. However the meaning of literacy goes beyond the mere ability to read and write. UNESCO (2004) sees literacy as the ability to identify, understand, interpret, create, communicate, compute and use printed and written materials associated with varying contexts. Literacy involves a continuum of learning to enable individuals to achieve their goals, develop their knowledge and potential, and to participate fully in the wider society.

The National Policy on Education in Nigeria places strong emphasis on mass literacy campaigns (FGN, 2004, 2008). Despite such emphasis, there was a decreasing rate of literacy in Nigeria. For example, the National Empowerment Development Strategy (2005) put the literacy rate in Nigeria at 57%, as against 64.1% in 1999 and 71.9% in

1991. However, in a most recent National Bureaus for Statistics Survey reported a 58% literacy rate in Nigeria which showed a marginal increase from the 2005 findings of the National Empowerment Development Strategy (NLS, 2010).

Also the National Bureau of Statistics in 2006 found that 46.7% of Nigerians are purely illiterate, while 53.3% are literate in the use of English language. A breakdown of the study also revealed that 61.3% of the literate population in Nigeria are male while 38.7% are female (NBS, 2006). Probing further to see the literacy level according to the geopolitical zones in Nigeria, the National Literacy Survey (2010) by the National Bureau for Statistics revealed that the Southeast geo-political zone has a 76% literacy rate, followed by the South-South with 74%, then southwest 69%, the North-Central 56%; Northeast 42% and the Northwest 31%. The data also revealed that Sokoto state had the least literacy rate with 22% while Lagos had the highest literacy rate with 70%. This suggests that even though there was a marginal increase in the literacy levels in the 2010 surveys, there is still need to increase the literacy levels in Nigeria.

1.6: Nigerian Educational System

The Federal Government of Nigeria regards education as an instrument for effecting social change and national development. The Nigerian philosophy of education is based on the development of the individuals into sound and effective citizens and the provision of equal educational opportunities for all citizens at primary, secondary and tertiary levels (FGN, 2004). The Ministry of Education is the government body charged with the responsibilities of regulating procedures and maintaining standards in all Nigerian schools. The Nigerian education system has the following components.

1.6.1: *Nursery Education*

Pre-primary education is a prominent component of the Nigeria educational system. It is a foundational training pupils receive before going to primary school and is considered an indispensable tool for the future life-long education for students (FGN, 2004). It provides Day Care Centres and Nursery Schools to children from aged 2 to 6 years and is enriched by the informal, traditional up-bringing given to children. Nursery schools are run by private proprietors. However, the Federal Government of Nigeria provides policy guidelines and supervision for the implementation of education at this level (FGN, 2008).

1.6.2: *Primary Education*

Primary education begins at the age of 6 for the majority of Nigerians and goes for 9 years. This system is divided into three stages (called basis). The lower basis is the first three years, the middle basis which is the next three year, while the upper basis is the former Junior Secondary School system which constitute the last three years (FGN, 2008). The curriculum at each of the basis is more activity based (even though teachers maintain their traditional classroom instruction) in which students are supposed to learn basic technical skills that will enable them to seek employment at the end of 9 years (FGN, 2004, 2008). This education component is run by the state and local governments; however the Federal Government of Nigeria gives licenses to private proprietors to run their schools.

The Development of human capital of young Nigerians is vital to improving the Nigerian dwindling economic growth (Omosewo, & Akanmu, 2013). These young Nigerians need the twenty-first century skills and knowledge to create successful ventures and to spur innovation to develop the country's economy to compete with the developed world. In view of these, it was recommended at the presidential summit on the State of Education in Nigeria held in October, 2010 that the number of subjects offered for Basic Education should be reduced to between 6 and 13 in line with international practices. The new framework, therefore, identified and groups of related disciplines together to become one, thereby, achieving a reduction in subjects listing. The newly revised structure adopted by stakeholders consists of 8 subjects for primary 1-3, 9 subjects for primary 4-6 and 10 subjects for Junior Secondary School JSS 1-3. These include English language, Mathematics, Cultural and Creative Arts and one Nigerian Language as compulsory subjects in the curriculum.

1.6.3: Secondary Education

Students spend three years in Senior Secondary School. At this stage students are prepared for technical skills required for higher education (FGN, 2008). Private organizations, state governments and the Federal Government operate Senior Secondary School in Nigeria. With the introduction of 9-3-4 system of education in Nigeria, students enter Senior Secondary School after completing a minimum of nine years of primary education and having passed a prescribed National Entrance Examination (FGN, 2008).

Similarly, to consolidate the gains of the present 9-Year Basic Education programme as well as ensure the actualization of Federal Government's agenda for national development, Nigerian Educational Research and Development Council (NERDC) developed a new curriculum structure for Senior Secondary School (SSS) in Nigeria. According to Omosewo, and Akanmu, (2013) the new Senior Secondary Education Curriculum (SSEC) was systematically connected with the contents of the present Junior Secondary Education Curriculum (JSEC). This was aimed at solidifying the gains of the 9-3-4 system of education in Nigeria.

The NERDC (2008) captured the philosophy, structure and basic features of the new SSEC. The philosophy and the structure of the SSEC was aimed at ensuring that every senior secondary education graduate should be well prepared for higher education as well as acquire relevant functional trade/ entrepreneurship skills needed for poverty eradication, job creation and wealth generation. This will, according to Orji (2010), strengthen further the foundations for ethical, moral and civic values acquired at the basic education level and as contained in the National policy on education (FGN, 2004).

According to Orji (2010) and UBE, (2011), the curriculum was enriched with contents necessary for the acquisition of entrepreneurship skills, strategic communication skills and positive national values with the hope that the new breeds of school leavers would have the spirit of enterprise and industry. The structure comprises a group of 5 compulsory core subjects and an option of selecting from any of four distinct fields of studies (Sciences/mathematics, Art/Humanities, Business Studies and Technology) (NERDC, 2008), as shown in table 1.1 below.

Table 1.1: Subject Structure Senior Secondary School Education Curriculum in Nigeria

S/N	*Field*	*Subjects Offered*
1	*Compulsory subjects*	*English Language, General mathematics, Trade/Entrepreneurship, Computer Studies/ICT and Civic Education.*
2	*Science/Mathematics*	*Biology, Chemistry, Physics, Further Mathematics, Agriculture, Physical Education, Health Education and Computer Studies/ICT.*
3	*Arts/Humanities*	*Nigerian Languages, Literature in English, Geography, Government, Islamic Studies History, Visual Arts, Music, French, Economics and Christian Religious Studies.*
4	*Business Studies*	*Accounting, Store management, Office Practice, Insurance, Commerce*
5	*Technology*	*Technical drawing, General Metal Work, Basic Electricity, Electronics, Auto-Mechanics, Building Construction, Wood-work, Home Management, Food and Nutrition, Clothing and Textiles.*

1.6.4: Teacher Education in Nigeria

The training of highly motivated, conscientious and successful classroom teachers at all educational levels was well emphasised in the objective of Nigerian teacher education as spelt out in the National Policy on Education (FGN, 1998). Teacher education program in Nigeria was developed with the aim of equipping teachers with intellectual competencies and skills that would enable them develop and develop in their students the requisite educational and societal values (Jibrin, 2007).

The coming of the missionaries according to Fafunwa (1982), into Nigeria in the 1840s marked the beginnings of the development of modern western education system in the country. According to Taiwo (1980), the Church Missionary Society (CMS) established the first teacher training Institution in Abeokuta, western Nigeria, in 1859. The Baptist Mission also founded the Baptist Training College Ogbomoso in 1897, with the Wesleyan Mission establishing the Wesley College in Ibadan in

1918. In the Eastern part of Nigeria, the Hope Waddell Institute was founded in Calabar in 1892. Later in 1909, the then Colonial Government established the Nasarawa Schools in Northern Nigeria. Katsina Teachers College and Toro Teachers Colleges were later established in 1927 and 1929 respectively in Northern Nigeria.

The grade 3 teacher's certificate was the qualification most of these institutions were awarding their graduates at those times. As the demand for quality education in Nigeria increased, such teachers training institutions were upgraded to award the teachers grade 2 certificates which were higher in standard and quality than the grade 3. The grade 1 teacher training was later introduced to meet up with the needs of the ambitious teachers who were willing to enhance their status to qualify of teaching in Secondary Schools.

The earliest curriculum for the early teacher training consisted of subjects like English, Arithmetic, Writing, Geography, Hygiene, General Studies, Geometry, Agriculture, Nature Study, and the Local Languages. From the Ashby commission report (1960), it was however observed that there were a lot of anomalies in the then colonial and missionary teacher training education curriculum. The commission observed, among other things, that the curriculum for the teachers training colleges was seen to be highly inadequate. Many teachers were un-certificated (teaching without teaching qualification) and improperly trained (Ashby, 1960).This resulted in the recommendation for massive expansion of teacher education programs aimed at upgrading the existing teaching force (Jibrin, 2007) from grade 2 teachers to Nigerian certificate in Education (NCE) teachers. This brought about the emergence of Advanced Teachers Colleges, which later metamorphosed into Colleges of Education.

The first group of these Advanced Teachers Colleges designed and established by the Federal Government with the assistance of UNESCO, were meant to produce well-qualified non-university graduate teachers for secondary schools to replace the older well established grade 2 teachers (UNESCO, 1996). The scheme provided teachers with the NCE that are of good quality to meet the educational needs of its citizens. The number of these colleges gradually increased to cater for expansions in demands for qualified teachers. Some of these colleges offered possibilities for teachers upgrading to bachelor of education degrees. The duration of the NCE is usually three years for the full time students, while the part time students spend upwards to five years to complete their programme of studies, while duration for the B.Ed. degrees was for four years of full-time study.

Universities established prior to independence, at independence and post-independence, also provided teacher education programs. Similarly, Polytechnics provide teacher education programmes in the areas of Technical and Vocational Education at both the NCE and degree levels. The National Teachers Institute a body set up to oversee the certification of teachers grade 2, was also to provide professional training and in-service teachers upgrading programs leading to the NCE by Distant Learning.

As the need for professional teachers increased, and the desire to meet the growing population of students in the Nigerian schools, other institutions were also mandated to provide teacher education programs in Nigeria. This led to the establishment of many distance learning and long vacation training programs to help unqualified teachers to obtain not just the NCE, but also degrees. However; the Colleges of education were the providers of the bulk of professionally trained teachers in Nigeria particularly for the primary and junior secondary schools (UNESCO, 2005).

Minimum Teaching Qualification in Nigerian Schools: The National Policy on Education FGN (1998) stated that, all teachers in educational institutions in Nigeria shall be professionally trained. Teacher education shall be structured to equip teachers for the effective performance of their duties (Jibrin, 2007). Since no educational system can raise above the quality its teachers, the policy pegged the minimum qualification for entry into teaching profession in Nigerian schools to be the Nigeria Certificate in Education (NCE) (FGN, 1998 NCCE, 1996) as the minimum requirement for registration as the teacher in Nigeria (TRCN (2005).

Jibrin (2007) in his report on the National Council of Colleges Education (NCCE) minimum standard for teaching in Nigeria stated that, to establish standard and quality in the development of teachers in Nigeria, all the Colleges of Education are to use a uniform curriculum for the training and development of teachers to ensure uniformity and quality. Several educational experts and researchers supported the NCCE stand on the uniform standard in teacher education development in Nigeria (Lassa, 1996; Obanya, 2004).

1.6.5: Tertiary Education

The Federal Government has majority control of university education in Nigeria. There are over 80 universities in Nigeria spread across the various states. Recent statistics reveal that there are 36 Federal universities, 30 state universities and over 24 private universities currently operating in Nigeria. In addition to these universities there are 13 Federal and 14 State Colleges of Education, Polytechnics, Monotechnics, Colleges of Agriculture, and Colleges of Nursing and Midwifery spread across all states. These institutions are established to train technical and middle-level manpower for Nigerian scientific and technological development.

1.7: Nigerian Educational Reforms

All over the world, nations have had to review their educational systems to bring about the most desired change and development. This stems from the realization that education is the major instrument for social change (Aluede, 2009). Imogie (2007) is of the view that education in Nigeria is much sought after by both students and their parents.

The Nigerian educational system has witnessed series of reforms in its policies and programs in recent years. These reforms are made because of the quest of Nigerian to provide quality and profitable education for its citizens. They also aimed to provide meaningful educational program for the Nigerian child (FGN, 2008). Similarly, these reforms in the Nigerian educational system are aimed at making Nigeria a country its citizen will desire and be proud to belong to, and also allow Nigeria to compete in the developed world (Aluade, 2009).

However, one can also add that with all the development and reforms in the Nigerian educational system, there had been little or no progress in students' achievement as seen in the continued percentage failures of students in most national examinations. Prominent among the educational reform projects in Nigeria since independence is the introduction of the Universal Primary Education of 1976, and the Universal Basic Education of 2004. Apart from these reform programs there were also reforms known as the 6-3-3-4 and the 9-3-4 systems of education. The following sections briefly discuss these latter reforms.

1.7.1: The 6-3-3-4 System of Education in Nigeria

The history of the 6-3-3-4 system of education dates back to 8th September 1969 during the International Literacy Day when the then Federal Commissioner for Education inaugurated a conference which formulated the ideas leading to the 6-3-3-4 program (Adaralegbe, 1971). The program was conceived as an instrument for national unity because of the lopsided educational development in Nigeria among the various regional governments of that time. Similarly, a critical examination of the formal education system in Nigeria before and after independence suggests an inadequate and unsatisfactory education system to the aspirations of Nigerians (Fafunwa, 1982; Nduka, 1965; Obayan, 1979).

Therefore in a bid to check these abnormalities, the then Federal Government of Nigeria adopted education as an instrument for effecting national development. Thus, it is stated in its National policy on Education FGN (1981) that**:**

> *Education goals in terms of its relevance to the need of the individual as well as in terms of the kind of society desired in relation to the environment and realities of the modern world and rapid social changes should be clearly set out. (p.5)*

This goal was designed to inject functionality and balance in the Nigerian educational system. It is referred to as functional education, because it enables its recipients to function economically, socially, morally, intellectually and politically. The system was fashioned to produce graduates who would be able to make use of their hands, head and the heart (the 3Hs of education). When it was finally introduced in 1982, there had been inputs by various sectors of the Nigerian professional community.

This system of education was seen as a laudable program capable of ushering in an educational revolution in Nigeria. Uwaifo and Udinn (2009) opined that this educational system in itself is a conscious effort of matching and merging academic and vocational education programs together.

The 6-3-3-4 system of education is a type of educational system wherein the students spend six years in the primary school, three years in the Junior Secondary School, three years in the Senior Secondary School, and four years in tertiary institutions (Adeyinka, 1988).

Parallel to the 6-3-3-4 system of education, the Federal Government of Nigeria became conscious of the dangers of disparity in educational development to a nation and therefore introduced the Universal Primary Education (UPE) scheme throughout the Federation in 1976. The differences that existed in the different regions were of major concern to the Federal Government of Nigeria (Itedjere, 1997).Thereafter; there was the regularization of compulsory primary education system throughout Nigeria. Subsequently a compulsory education program for all Nigerians between the ages 6 and 13 years was adopted (Aluade, 2009).

Sad to say that this scheme failed; perhaps, because, the Federal Government of Nigeria underestimated the number of pupils that would want to benefit from such a program, and underestimated the number of teachers, school buildings and the amount of money that would be required to make the program functional (Aluade, 2009; Itedjere, 1997). However, the recent relaunching of a similar program, the

Universal Basis Education scheme by the Federal Government of Nigeria suggested that more careful planning has taken place (Aluede, 2009).

1.7.2: The 9-3-4 System of Education

The 9-3-4 system of education took off in Sokoto State in the year 2006 which involved the first nine years of basic and compulsory education, three years in Senior Secondary School, and four years in tertiary institutions. It was designed to streamline the over-crowded nature of subjects offered at the basic education level (Aderinoye, 2007; Oni, 2006).

The National Council on Education (NCE) at its 52nd meeting in Ibadan approved a subject structure as the new 9-year basic education curriculum which had been developed by the National Educational Research and Development Council (NERDC) (Kayode, 2006; Uwaifo & Udinn, 2009). According to the document released by the National Council on Education in their 52nd meeting reported by Uwaifo and Udinn (2009), the new curriculum was expected to be realigned to meet the Millennium Development Goals (MDGs), Education for All (EFA) and the National Economic Enhancement Development Strategies (NEEDS).

The implementation arrangement which was being considered by the Federal Government of Nigeria for the new curriculum was to introduce the new curriculum only in Primary 1 and Junior Secondary School 1 (as it implies in the Nigerian educational system) in September 2006. The FGN was also to provide massive orientation programs and systematics training of teacher to prepare them for the new curriculum (Omovo, 2006; Uwaifo & Udinn, 2009).

Together with the 9-3-4 system of education, the concept of Universal Basic Education (UBE) was conceived. It was viewed and conceptualized as the forms of organized education and training introduced to equip Nigerian children to cope in their environment and be effective members of the society similar to the objectives of the 6-3-3-4 system of education (Adeyemi, 2004; Arikewuyo & Onanuga, 2005). The Jomtien Declaration and Framework of Action on Education for All (1990) viewed Basic Education as a process which encourages close articulation of formal, non-formal and informal approaches to education and structures for an all-rounded development of human and capital potentials.

In view of these developments, the National Policy on Education stated clearly the importance of UBE to Nigeria and that this form of education consists of 9-year compulsory formal schooling (Aderinoye, 2007). It also included adult literacy and non-formal education, skill acquisition programs and the education for special groups such as nomads and migrants, Almajiri, street children and disabled people (FGN, 2004).

1.8: Significance of the Study

This study has the potential to identify key factors in sustaining quality pedagogy, an issue of global concern (Cascant & Kelber, 2012; Sumner & Wiemann, 2012; United Nations, 2013), and particularly in Nigeria, where it is confirmed by literature and by experience that students at all levels of education find mathematics difficult to learn (Blumende, 2001; FGN, 2006; Ogunsaju, 2004) and hence performed below expectations in both classroom assessments and in national examinations (Blumende, 2001; Imogie, 1990; Iyamu & Aduwa , 2004).

Whilst organisational, curriculum and assessment practices have undergone significant reform in recent decades, a similar focus on improving pedagogy has only emerged during the past few years (Hayes, et al., 2006). The centrality of pedagogy in teachers' work means that this research can inform the reform of teacher education programs and provide support for teacher induction and socialisation of teachers into their practice.

The findings of this research might also guide system level refinement of school processes for the professional development of all teachers. Expected outcomes of this research will be used as papers for conference presentations, journal publications, and by colleagues in other universities and colleges across Nigeria and beyond who could build on this work to examine the effectiveness of Productive Pedagogies to teachers and also to pre-service teacher education.

1.9: Organisation of the Thesis

Chapter 1 provides an introduction to the issues of the current research focus on classroom teaching in Nigerian secondary schools. It also states the research aims, the context of the study, significance of the research, and thesis organisation.

Chapter 2 reviews the literature in relation to classroom teaching in Nigeria. The chapter specifically examined the concept of classroom teaching in the context of the Nigerian classroom and the reforms required for facilitating effective classroom instruction. Finally, the chapter looks at the teachers' reflections as means for improving pedagogy, the concept of Productive Pedagogies and its dimensions.

Chapter 3 considers the methodological context of this research. The chapter provides an explanation about the interpretative paradigm of qualitative research, in particular, the case study approach. In addition, since this research utilises more than one instrument in an attempt to achieve triangulation of the data, each method, its sample and the implementation are detailed. The chapter also discusses the data analysis and the interpretative processes employed through the grounded theory approach to analyse the data collected. Finally, the Chapter addresses issues of research quality and ethical considerations.

The findings of this research are presented in Chapters 4, 5, and 6. Chapter 4 presents the findings on the scaffolding provided to the participating teachers to help their understanding and implementation of Productive Pedagogies. Chapter 5 presents the findings on the implementation and the reflections of the participating teachers on the benefits obtained in using Productive Pedagogies. Chapter 6 presents the findings related to students' perceptions of their classroom engagement in mathematics using Productive Pedagogies framework.

Lastly, Chapter 7 provides a detailed discussion regarding the research findings and draws conclusions about this research. In this chapter, key findings are discussed in relation to the research aims. It discusses, in turn, the relationships between current research findings and previous studies, and draws links between the findings and some particular characteristics of Nigerian society and education systems. Finally, the chapter discusses limitations and directions for further research.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.0: Introduction

This study aimed to investigate the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. In this chapter the following areas of literature are reviewed. First, the literature on the Nigerian mathematics classroom is examined to identify the forms of teaching strategies employed by Nigerian mathematics teachers. Second, the literature that identifies needed reforms in Nigerian mathematics classrooms is considered. Third, this chapter examines the role of teacher reflection on their practice as a means of improving teaching, and finally, the Productive Pedagogies framework and its dimensions is reviewed in some detail.

2.1: Traditional Mathematics Classroom

Teaching of mathematics in Nigeria is characterized by the traditional formula- based approach with emphasis on computation with little reference to mathematical reasoning and problem solving. According to the Nigerian Education and Research Development Council (NERDC) this type of teaching is mechanical and teacher-centred; it is out-dated since in this approach mathematics is taught and learned instrumentally by rote and memorization, without meaningful understanding of the concepts taught (NERDC, 2013). Students become frustrated in the face of apparently meaningless symbols that are manipulated. They regard mathematics as a static subject with a set of algorithms to be applied mechanically, as it is learnt by drill and practice (Igbokwe 2000; NERDC, 2013; Ogunbiyi, 2004).

Many national examinations conducted in Nigeria suggest that a large percentage of students are finding it difficult to perform moderately complex tasks or employ higher order thinking skills to solve mathematical problems (Adedayo, 2001). This is as a result of the unskilfulness of mathematics teachers (Mustapha, 2001). Nneji (1998) suggests that such teachers find it difficult to help their students make use of higher order thinking skills to deal with complex mathematical tasks. McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers and Cooney (1987) also suggested that mathematics teachers sometimes feel satisfied when they are able to make their students successfully perform routine, computational tasks using formulas without checking whether these students can consistently and successfully solve problems. Hence, more complex tasks that require students' reconstruction of knowledge to solve problems sometimes become a serious challenge to the students (Dossey, Mullis, Lindquist, & Chambers, 1988).

Many other researchers globally had contributed to the discussions on the traditional, didactic teaching strategies in their countries. The findings of these researchers could also be applied to the Nigerian mathematics classrooms. For example, Porter, Floden, Freeman, and Schmidt (1988) asserted that most mathematics teachers concentrate their attentions on developing computational skills. This reflects the traditional mathematics classroom instruction in Nigeria where the development of computational skills by mathematics teachers occupies greater part of classroom teaching (NERDC, 2013). Similarly, Schoenfeld (1988) identified mechanical procedures and symbolic manipulation as believed by most mathematics teachers to mean mathematical learning; even in 'good' classrooms.

Abimbade and Afolabi (2012) complained that some mathematics teachers have consistently stuck to their traditional teacher-centred mathematics teaching strategies in most Nigerian secondary schools. Similarly, Igbokwe (2000) and Ogunbiyi (2004) asserted that the traditional teaching strategy commonly used in teaching mathematics in Nigeria is due to the lack of adequate instructional materials and teachers' unskilfulness in the use of effective teaching strategies. For these teachers, mathematics teaching simply implies memorizing rule-bound algorithmic skills and procedures that are devoid of context or meaning (McNeil, 1986; Sedlak, Wheeler, Pullin, & Cusick, 1986). This type of classroom teaching illustrates the trivialized, superficial learning that pervades the Nigerian mathematics classrooms (NERDC, 2013).

With respect to these challenges, Mansaray and Amosun (2002) suggested that it is necessary for mathematics teachers to focus their teaching towards developing students' critical thinking capabilities in order to succeed in resolving the challenges facing their classroom instruction. Similarly, Abimbade and Afolabi (2012) suggested that in order to develop students' critical thinking, mathematics teachers should be capable of using teaching strategies that elicit thought provoking responses from their students. To develop such critical thinking capabilities of students, Obanya (1999) suggested that there is need for emphasizing teaching strategies that encouraged critical analysis of issues, and a democratic classroom atmosphere that encourages exchange of ideas and opinions among students, which is in line with the Intellectual Quality dimension of Productive Pedagogies.

Research studies suggest that effective modern teaching strategies should be based on certain normative principles. Some of these normative principles suggested by researchers include: proceeding from the simple to the complex, from the easy to the difficult, from concrete to abstract, from known to unknown, from the particular to the general (Augustine, Gruber, & Hanson, 1989-1990), from whole to part, from empirical to rational, from psychological to logical, from actual to representative (Oyeniran, 2003) and from common language to subject language (Kochhar, 1985).

Felder and Brent (2003) observed that the characteristics of high levels of secondary school students' intellectual development and deep approach to mathematics classroom learning depend on the skills employed by the mathematics teachers. While Afolabi (2008) was of the view that if mathematics teachers adopt productive instructional strategies in their teaching, the potency of improving the intellectual development of their students is high. This suggests that students' intellectual development and deep approach to mathematics classroom instruction involve helping students take responsibility for their learning and making attempts to understand new knowledge in the context of their prior knowledge and experience (Felder & Brent 2003; Lloyd, 1996, 1999). This assertion is in line with the students' background knowledge of Connectedness in Productive Pedagogies.

In view of these issues, the Federal Government of Nigeria through its National Policy on Education spelt out the national education goals to include cultivating in students the act of inquiry, problem solving and having a rational mind for national development (FGN, 2008). This suggests that these National goals for mathematics instruction should aim at helping students acquire appropriate mental, physical and social skill, abilities and competencies that will equip them to live and contribute meaningfully to the development of their society. In view of these points, Bature and Zuya (2008) suggested that, mathematics teachers should teach mathematics through the hands-on approach where students are placed in problem solving situations, surrounded by appropriate materials that will enable them to process information in their efforts to find solutions to their problems.

For example, the Federal Ministry of Education in Nigeria had constantly emphasised the need for mathematics teachers to use field studies, and guided discovery as teaching strategies to help improved students' conceptual thinking (Ibe & Nwosu 2003). In the same study, Ibe and Nwosu discovered that the guided inquiry strategy was significantly better for students' achievements than demonstration and conventional (lecture) strategies and therefore advised that mathematics teachers should adopt the former strategies during classroom instruction.

2.2: Reforming Mathematics Classroom Practice

The mathematics classroom environment that is traditional is one in which the teacher is believed to be in possession or in control of the growth and development of understandings. In this type of classrooms, students are asked to individually solve exercises in a teacher-dominated environment (Lyman & Foyle, 1990; Slavin, 1990). Research results have indicated that in these traditional teacher monopolized classroom, teachers are seen to dominate classroom discussion and maintain structures that heavily rely on teacher-student recitation (Good & Brophy, 2000).

In most Nigerian mathematics classrooms, Adamu (1992) asserted that these traditional patterns of mathematics teaching had remained largely unchanged and unchallenged. In his study, Adamu posited that these typical pedagogical patterns reflect the authoritarian, didactic approach to classroom teaching where the mathematics teacher monopolized classroom activities. The effect of this was described by NERDC (2013) that the natural curiosities of students who are eager to understand their environment are often diminished by instructions that discourage inquiry or students' self-discovery learning. This is due to lack of expertise by most mathematics teachers who use the traditional approach during classroom instruction. Friere (1996) described this traditional classroom as similar to a transaction in a bank. Instead of assisting students to develop knowledge with other students during classroom instructions, the teacher deposits information, which students patiently receive, memorize, and repeat. This is the 'banking' concept of education, in which the scope of action allows students to receive, file, and store deposits of facts delivered to them by the teacher.

The traditional teaching strategies still being adopted by mathematics teachers in Nigeria are based on the objectivist epistemology which has been questioned by many researchers globally and locally (Afolabi, 2001; Okwo, 2000; Usman, 2001). One of the major challenges in these traditional teaching strategies is that the teacher's perspective becomes the major determining factor in the resulting classroom environment (Ezekute, 2000; Liverpool 2001; Udovic, Morris, Dickman, Postlethwait & Wetherwax, 2002; World Bank, 2002).

According to Nelson (1997), a widely used description of the traditional pattern in which the teacher's interpretations prevail is the initiation-reply-evaluation sequence.

In this pattern, students respond to ideas and questions that are mostly teacher-generated. As a result, many students acquire procedural knowledge for step-by-step solutions to mathematical problems without having the understanding of the conceptual rationale of the concept learnt (Cauley, 1988; Cobb, Wood, & Yackel, 1993). This is as a result of the classroom environment provided by mathematics teachers especially in Nigerian classrooms (Adeyemo, Adegbola & Oke, 2009; Olowoye, 1990).

Obviously this pedagogical pattern is not equipping the students mathematically to live effectively in our contemporary age of science and technology as stipulated in the National Policy on Education (FME, 1998; NERDC, 2013). Similarly, the unsatisfactory performance of students in mathematics in Nigeria today could be the result of this traditional approach to teaching and the poor classroom environment created by mathematics teachers (Olosunde & Akinpelu, 2012). This suggests that the replacement of classroom teaching that supports drill and memorization of mathematical procedures with classroom teaching that is student-centred and that supports students' engagement with conceptual issues of inquiry, collaboration and problem solving should be encouraged during classroom instruction.

Consequently, this also implies that there is the need to shift from the traditional teacher-centred classroom instruction to more student-centred classroom instruction. Wilson and Lloyd (2000) were of the view that this pattern of classroom teaching can be altered if mathematics teachers and their students are willing to shift their roles and beliefs. For them, shifting the expectations of traditional classroom teaching to a more engaged system where everyone is involved makes teaching real and engaging to the students.

Empirical studies globally had shown that student engagement in mathematics sense-making activities and the development of mathematical insight and understanding helps improve students learning of mathematics. This also improved their participation and engagement in classroom activities (Baroody, 2004; Clements, Sarama, & DiBase, 2004; NCTM, 2000). This suggests that mathematics teachers who want to shift from the traditional mathematics classroom to more student-centred classrooms approaches should learn to adopt strategies that will encourage interactions, collaboration, students' participation and engagement between the teachers and his students and between students to a greater extent.

Similarly, Wilson and Lloyd (2000) were of the view that this concept of shift from the teachers' control of the classroom teaching to a more relaxed classroom environment where learning will be done collaboratively in a more non-authoritative way does not necessarily imply that the mathematics teachers' authority is completely discounted. Rather, it makes mathematics teachers emphasize student involvement by decreasing their traditional role of givers of knowledge and playing a more relaxed role of guiding students' knowledge and learning (Wilson & Lloyd, 2000). These are classrooms where students' ideas are solicited and valued as important contributions to developing understanding of concepts and problems. In these classrooms, teachers becomes collaborating members and the learning environment evolves as a result of interaction between teachers and students and between students as they engage in profitable mathematics discussions on the mathematical content (Simon, 1995)

Theories of teaching and learning based on constructivist principles suggest that students as active learners view mathematical learning as active manipulation of meanings (Davis, Maher, & Noddings, 1990). This means that mathematics teachers desiring to achieve these constructivist principles in their classroom instruction should be able to provide learning environments that will help challenge their students' critical thinking. This constructivist epistemology which guides students' thinking suggests a shift from the traditional teaching strategies which seek to transmit fixed, well-structured knowledge with a firm external control of content, sequence and pace of learning by the mathematics teacher to a more relaxed, collaborative and participative student-centred learning where students construct their own knowledge, learn more independently and in the process acquire self-reliance (Heinich, Molenda, Russell & Smaldino, 2001).

Nesher and Kilpatrick (1990) state that Piaget's contributions are essentially built on the basic idea that knowledge derives from the adaptation of the individual to the environment, is much richer than knowledge received by mere recitations or procedural presentation of facts by the traditional mathematics teacher. This principle suggests that rich knowledge can be traced to students' ability to interact with the objects around them. This also suggests that to encourage such interactions among students mathematics teachers should be able to provide activities through which students can use their experiences to gain purposeful knowledge that can later be applied in other situations that may arise in the future.

Apart from students' interaction with the environment within and outside the classroom, social interactions among all participants also play a major role in the learning that takes place in a mathematics classroom. This view reflects Vygotskian ideas. This offers a perspective different from the Piagetian view of individual construction of knowledge. Effective mathematics classroom instruction is based on the application of Vygotsky's ideas concerning assisted performance. Smagorinsky (1995) was of the view that "*A student can perform at a developmentally more advanced level when assisted" (*p. 195*)* than when acting alone and a *"learner has a range of potentials rather than some fixed state of ability."* (p. 195)

The work of Bruner, spanning decades, provides another perspective from which to view current mathematics classroom reforms. As we attempt to provide students with meaningful learning environments, Bruner's (1990) was of the view that "*Culturally adapted way of life depends upon shared meanings and shared modes of discourse for negotiating differences in meaning and interpretation" (*p. 13). The view of Brunner centred on the concept of shared ideas among students and negotiation between learners during mathematics instruction.

The NCTM Standards documents and the Queensland Longitudinal Study on Productive Pedagogies (Education Queensland, 2002) supported this statement in its emphasis on classroom discourse and the sharing of mathematical ideas between students and between teachers and students. Learning in this context is collaborative and necessarily relies on the sharing of knowledge among members of the collaborative group. The implication of these investigations in mathematics classrooms is that created meanings by individuals must be negotiated with others to enhance knowledge and understanding within a collaborative setting. The idea of negotiation is part of the NCTM Professional Standards (1991) which asserted that

> *Students' learning of mathematics is enhanced in a learning environment that is built as a community of learners collaborating together to make sense of their mathematical ideas. (*p. 58*)*

This supported the concept of substantive conversation of Productive Pedagogies that looks at learning as more of the interaction between learners.

2.3: Teachers Reflection on their Practice

Reflection on practice is an effective means of teachers' growth and in reforming pedagogy. Researchers like Doyle (1990), Kwon and Orrill (2007) and Nelson (1993) considered reflective practices as focusing on the effectiveness of specific teaching strategies adopted by classroom teachers with the view to promoting their professional development. Reflection could be viewed as a situation where one examines the benefits and failures of a particular project or activity in terms of the situation, behaviour, practices, effectiveness, and accomplishments (Valverde, 1982).

Reflection on practice could be achieved through self-evaluation that involves active, persistent, and careful consideration and contemplation of the practitioner's beliefs and knowledge and leads to professional development, growth, and greater understanding of self and the profession (Valverde, 1982). Valverde went further to suggest that the self-examination during teachers' or practitioners' reflections must be constructive, deliberate, and undertaken periodically. Similarly, Kottamp (1990) viewed reflection as:

> a *cycle of paying deliberate attention to one's own actions in relation to intentions for the purpose of expanding one's opinions and making decisions about improved ways of acting in the future, or in the midst of the action itself. (p. 182)*

Reflection on classroom teaching could take place at any time. The reflection in this research had to do with what the teachers felt after using the Productive Pedagogies framework to achieved quality classroom instruction. It suffices to suggest that the most important reflection in mathematics instruction is the one that occurs immediately after classroom instruction. This is in line with the view of Cooper (1999) who believed that effective reflection occurs when teachers takes their mind away from the hustle and bustle of classroom interactions. This is because effective reflection involves self-evaluation through critical analysis of teaching decisions and their outcomes to determine how effectively the classroom teaching strategies were handled, and how beneficial they were to the teacher and the students in achieving the objectives of the lesson or activity (Cooper, 1999).

Dewey (1933) noted that reflection is an essential component of professional development and can place a novice teacher on the path to becoming an expert teacher. There is a connection between reflection and constructivism (Schunk, 2012). This is because it is through reflection that mathematics teachers are able to mentally construct new knowledge about themselves, their teaching, their students and they can continually improve and modify their concept of effective classroom instruction for the betterment of the entire system (Snowman, McCown & Biehler, 2012). Similarly, Osterman and Kottkamp (2004) were of the view that reflective practices incorporate key elements of constructivism, experiential learning, and situated cognitive learning experiences. Bailey, Curtis, and Nunan (2001) saw reflective practices in two dimensions. This includes; reflection-in-action and reflection-on action, they were of the view that, in reflection-in-action, teachers continually examine their teaching practices for the purpose of making suitable changes in their pedagogy. On reflection-on-action Baily et al were of the view that teachers organized their teaching practice well in advance and then evaluate the implementation after the instruction.

Critical reflection, as opposed to mere reflection, refers to how teachers learn to challenge their own teaching beliefs in a critical self-analysis and become responsible for their actions (Korthagen, 1993; Sockman & Sharma, 2008). These experiences allow teachers to develop deeper understanding about themselves, their teaching practices and their students. Liou (2001) was of the view that critical reflection increases mathematics teachers' awareness about their own teaching and encouraged positive changes and development in teachers teaching capabilities. Yang (2009) asserted that

> *Critical reflection fosters the most effective teacher interaction in a professional setting by encouraging teachers to take a stand through questioning and challenging others' underlying assumptions. (p.11)*

The term community of practice comes from theories based on the idea of learning as social participation. Wenger (1998) in Coto and Dirckinck-Holmfeld (2008) view community of practice as:

> *The process of social learning that occurs when people who have a common interest collaborate over an extended period to share ideas, values, beliefs, languages, and ways of doing things. (p.55*)

Community of practice can play integral and important roles in teacher professional development programs. Schlager and Fusco (2004) were of the view that teachers' professional development is "*a process of learning how to put knowledge into practice through engagement in practice within a community of practitioners" (p.4).*

The community of practice through collaboration between teachers help to raise teacher professional performance during classroom instruction. This is because teachers have the opportunity to gain access to new information, clarify their ideas and beliefs, examine different ways of thinking about teaching (Rhodes & Beneicke, 2002), defend and criticise one another thoughts and reflect on their own practice and practice of others professional colleagues. This suggest that, community of practice provides an alternative for professional learning experience that involves participation in a community of practice, and help to encourage the practitioner of new norms, values, and practices. This also suggests that, the potential of support and collaboration through the community of practice, based on the notions of shared knowledge construction is an important opportunity pre-service and in-service teachers should not afford to miss.

In their study, Moon (2004) coined the term '*common sense reflection*' to describe one basic level of thinking: Roffey-Barentsen and Malthouse (2009) were of the view that such *common sense reflection* is

> *The thoughts that occur to us during our day-to-day living, perhaps following a different lesson or a particularly challenging student; It is the thoughts we cannot put down after a difficult encounter with an aggressive student or the muses we choose to have when we feel we could do better and try to work out exactly how. After these events you may think about the situation in terms of what went well and what did not. You could consider the behaviour of the students or how well a particular exercise went. (*p. 4)

Dewey (1933) contrasted 'routine action' with 'reflective action' where Pollard (2005) asserted that;

> *Routine action is guided by factors such as tradition, habit and authority" Reflective action, on the other hand, involves a willingness to engage in constant self-appraisal and development. Among other things it implies flexibility, rigorous analysis and social awareness.* (p.13)

This suggests that by implication routine action is relatively static and is not responsive to changing priorities, circumstance, and the needs of the learner. Hillier (2002) developed his perception of reflection by saying that reflective practices are developed with more purpose and structure. Hillier (2002) used the term '*critical reflection*' and concluded that, "*Without critical reflection, teaching will remain at best uninformed, and at worst ineffective, prejudiced and constraining*' (p.10).

Recent, research studies on teaching and learning had begun shifting focus from the traditional didactic classroom instruction where the teacher dictates what happened in the class to a more community based teaching practices. This has brought about the need to provide opportunities to make teachers development program which includes building on the prospective teachers' existing knowledge, beliefs and attitudes about teaching practices (Beattie, 2000). Research findings also suggested that in mathematics teacher education program, there is the need to acknowledged that changing the beliefs and practices of pre-service and in-service mathematics teachers should reflect a more constructivist approach to teaching (Grouws & Schultz, 1996; Mewborn, 1999).

Discussing theories of reflection begins at the constructive view of classroom teaching. This is because the trends and reforms in most mathematics classroom practice across the world today placed more emphasis on the constructivist views of teaching and learning as ways by which the design and the implementation of mathematics curriculum that encourage quality classroom teaching which understanding is builds (Frid, 2000). From a constructivist perspective, learning takes place as a result of students' personal construction of knowledge through active cognitive and social engagement in the students' experiential world (von Glasersfeld, 1995). This engagement involves the students' personal interpretation of the content, and the ability to reflect upon, physical and mental activities in order to create viable and important adaptable cognitive concepts in the classroom (Wood, 1995).

Similarly, Korthagen and Kessels (1999) in their own study also asserted that, a need for developing a more innovative and self-constructed approach to pedagogy for pre-service and in-service mathematics teachers during their teachers development program with particular emphasis on the development of reflective practices, inquiry-oriented activities, collaboration in a community of practice and interaction amongst the prospective mathematics teachers are very necessary.

2.4: Productive Pedagogies

The Queensland School Reforms Longitudinal Studies (QSRLS) (1999) viewed Productive Pedagogies as a sustained disciplinary inquiry focussed on powerful important ideas and concepts which are connected to students' experiences and the world in which they live. Luke (2002) viewed it as a framework of vocabularies that outlines characteristics of good teaching and effective pedagogies that support classroom practice.

Productive Pedagogies is believed to be a theoretical framework that enables teachers to reflect critically on their work, resulting in some benefits as identified by Gore, Griffiths, and Ladwig (2001). These include beneficial tools to engage teachers in personal reflection and substantive conversation about the link between students outcome and pedagogies, providing a shared vocabulary and common language for teachers to discuss their teaching learning activities, and providing a common ground for dialogue between teachers and students, students and students, teachers and the school, on how it will work best for improved intellectual and social outcomes for distinctive groups of students.

The comprehensive and multi-dimensional construct of Productive Pedagogies provides an analytical framework for more descriptive models of teaching practice that can be developed theoretically and applied in the professional development of teachers. Research studies demonstrated that this kind of teaching is quite scarce, in the sense that its popularity is yet to capture the interest of most classroom teachers, students, educators, researchers, educational managers and the government in general. However, the model has been utilised in several research studies. For example, Alsharif (2012) in Saudi Arabia and Tanko (2012) in Abu Dhabi have, in addition to other researchers, applied Productive Pedagogies in their studies.

Productive Pedagogies is not meant to develop an instrumentalist model for teaching practices in the classroom which can be followed mechanically. The Productive Pedagogies model does not provide ready-made techniques for teachers but rather it is an approach to create a place, space and vocabulary for teachers to begin talking about their classroom instruction (Atweh, 2007; Luke, 1997). It is not a magic formula, for example, that will solve all classroom problems, but rather it is a framework of vocabulary for staffroom discussion among teachers, in-service and pre-service training, for teachers to describe the various things they can do in their classrooms, the various options in their teaching repertoires that they have, and how this can help adjust the classroom setting for profitable outcomes (Atweh, 2007; Luke, 1997).

Productive Pedagogies is a framework that was developed by the Queensland School Reform Longitudinal Study (QSRLS) research team, which build upon the ground work of Newmann and Associates (1996), known as Authentic Pedagogies. Authentic Pedagogy offered significant general insights into how classroom instruction might be improved. However, Ladwig (2007) suggested that the quality of these Authentic Pedagogies does not readily translate into practical models for mathematics classroom instructional pedagogies.

Similarly, Gore et al. (2001) were of the view that Productive Pedagogies needs to come early in the teacher education program. This is because, in order to be more fully integrated into students' knowledge base for the teaching and learning process, teachers need to develop their skills of teaching. Therefore, if mathematics teachers are to treat Productive Pedagogies as foundational, then in all their efforts in mathematics teaching, Productive Pedagogies must be clearly positioned in the proper way during their teacher preparation programs (Gore et al., 2001). This also suggests that it should be used as a device to guide all aspects of mathematics teacher classroom instructions and be modelled into the pedagogies of teacher education practice and to their professional development programs (Gore et al., 2001).

While Productive Pedagogies appears to be a useful model for improving mathematics classroom instructions, given its strong relationship to both academic and social outcomes for students in schools, it seem also to have potential for reforming mathematics classroom instructions particularly in Nigerian secondary schools. For example, one of the most unresolved issues in Nigerian mathematics classrooms reforms today remains how to improve the pedagogical practices of mathematics teachers (Bajah, 1999; Oguniyi, 2009), reduce students' phobia for mathematics and the negative attitude exhibited by students and teachers towards mathematics and mathematics classrooms instructions in order to have sustainable educational outcomes (Bature & Bature, 2006). The introduction of Productive Pedagogies into the Nigerian classroom is believed (if properly implemented) will contribute to the solution of some of the Nigerian mathematics classroom problems.

Productive Pedagogies, developed by the Queensland School Reform Longitudinal Study research team, was built upon a very large body of educational researchers to bring about academically and socially equitable classroom teaching that will improve student learning outcomes (QSRLS, 2001) with a particular focus of extended the ground-breaking work of Newmann and Associates (1996). Research studies on the Newman and Associate (1996) ‘Authentic Pedagogy’ according to Ladwig (1998) has offered significant improvement into how teaching practice could be improved. However, Ladwig was of the view that the generic quality of’ the Authentic Pedagogy’ did not readily translate into practical models of classroom teaching pedagogies. This led to the development of a more comprehensive and multi-dimensional construct of a framework on pedagogies called Productive Pedagogies. This framework provided a more analytical and descriptive models that could be used to achieve quality classroom teaching. This model, according Ladwig (1998) and Atweh (2014), was developed theoretically and applied in the professional development of teachers.

The Queensland School Reforms Longitudinal Study was the most extensive observational study of classroom practices conducted in Australia. It was commissioned by Education Queensland and conducted by researchers from the School of Education, the University of Queensland, from 1998 to 2000. This study, which involved the observation of approximately 1000 classrooms over a period of 3 years, examined the links between classroom teaching and the improvements of students learning (Lingard, Hayes, Mills, & Christie, 2003). The principal objectives of the study were related to what was perceived to be the generally low levels of quality pedagogy and students learning outcomes in Queensland classrooms (Mill et al, 2010).

It was during the study according to Atweh, (2009) and Mill et al (2010) that the Productive Pedagogies and Productive Assessment frameworks emerged as research tools for exploring and evaluating classroom teaching pedagogies that have positive impact upon the academic and social outcomes of all students regardless of socio economic backgrounded. Similarly, it was during this period that the Productive Pedagogies framework was subsequently presented as a useful language for teachers to critically reflect on, and enhance, their practice towards improving student learning (Lingard, Hayes, Mills & Christie, 2003; Hayes, Mills, Christie, & Lingard, 2006).

On similar studies that have adopted Productive Pedagogies after its introduction in Queensland, Tanko, (2012) in United Arab Emirate was working with females students who were studying an introductory course in mathematics. In that study, Tanko adopted and action research approach to identify how students will develop their ideas in carrying out research using the principles of Productive Pedagogies. Particularly, Tanko was interested on the social Justice aspect of the Productive Pedagogies framework. The findings of that study suggested the traditional social Justices issues adopted into the teaching and learning of mathematics encourages students to take control of their own learning and find solutions to social justice problems in the real world around them.

Gore, Griffiths and Ladwig (2001) in a three-year intensive classroom observation of teachers in primary and secondary schools, were concerned with how student learning takes place in the classroom. In that study, they were not only interested in the academic activities of the students in the classroom, but also their social interaction with other students. Further, they were interested in identifying possible opportunities to enhance classroom instruction. Other studies conducted by these researchers also suggested that the Productive Pedagogies framework has the potentials of improving the pedagogy for both preservice and inservice teacher (Gore, Griffiths & Ladwig, 2002). In another study, the researchers measure the effects of a particular intervention on the pedagogy of practising teachers (Gore, et al., 2002). The study was designed to enrich the understanding of practice teachers on the Productive Pedagogies framework and for the teacher professional development by addressing the thorny question of the sustainability of impact across the career transition from student-teacher to practicing or professional teachers.

Similarly, Gore et al. (2004) were interested in finding out if Productive Pedagogies could be a better alternative for improving or achieving quality teaching. They used 30 students who were in their final year of a 4 year teacher education program to undertake an elective subject titled Teaching Better. At the end of the semester 10 out of the 30 students volunteer to have some of their internship lessons observed and coded. The students were also involved in the observation of the classroom teaching of their colleagues, using the scoring manual which covers the four dimensions of the Productive Pedagogies framework.

The findings of that study suggest that the Productive Pedagogies unit taken by these pre-service teachers helped promoted the idea that Productive Pedagogies could become a ‘normal’ part of students’ everyday planning and teaching by being mindful of the four dimensions. Similarly, three key themes were identified according to Gore et al (2004) from classroom experience of the participants. First, the participants tended to view Productive Pedagogies as additional rather than an integral part to teaching. Second, they view Productive Pedagogies as having specific applications rather that universal applicability. And finally, the participants were of the view that Productive Pedagogies was a valuable framework for teaching practice which came too late in their teacher education program.

In a similar, study on using Productive Pedagogies on teacher's development program, Alsharif, and Atweh (2012) used the framework with a group of final year preservice teachers at a teacher education college in Saudi Arabia. The students were introduced to the framework in a unit on mathematics education and were observed during the following semester in their field experience to ascertain their level of understanding and how they used it to achieved quality teaching. The findings of that study suggested that there was an improved level of acceptance of the framework by the preservice teachers which also brought about improvement in their planning for classroom instruction and in the actual classroom teaching. The findings also suggested that, the preservice teachers demonstrated a shift towards student-centred teaching as against the traditional teacher-centred teaching.

The situation in Saudi Arabia is not different to what prevails in Nigerian mathematics classrooms. It is only hope that when the study is introduced to the Nigerian classroom similar improvement will be observed. Secondly, the researcher is hoping to adopted the methodology of Gore et al (2004) and that of Alsharif, and Atweh (2012) to introduced Productive Pedagogies to a group of teachers in a Nigeria university, with the hope that this will improved not just the teaching ability or quality of the four teachers, but also to see if it will increase students engagement in mathematics which had been the challenge to most mathematics classroom teachers in Nigeria.

2.5: Dimensions and Elements of Productive Pedagogies

Productive Pedagogies are a four-dimensional normative framework for improving classroom instruction. The QSRLS (1999) presents four dimensions of classroom practice which are necessary conditions for achieving productive classroom instructions. Quality learning experience is acknowledged when mathematics teachers provide for their students, intellectually challenging materials that are relevant and connected to the children's lives, recognising that children learn in different ways and have different needs within a supportive learning environment. Before discussing in detail the four dimensions of Productive Pedagogies, below are the brief descriptions of its elements.

Table 2.1: The Dimensions of Productive Pedagogies and their Associated Elements Summarised by Atweh (2007)

ELEMENTS OF PRODUCTIVE PEDAGOGIES	DESCRIPTION
INTELLECTUAL QUALITY	
Higher Order Thinking	*Involves transformation of information and ideas. This transformation occurs when students combine facts and ideas to synthesize, generalise, explain, hypothesize or arrive at some conclusion or interpretation.*
Deep Knowledge	*Deep knowledge is concerned with the central ideas of a topic or discipline which are judged to be crucial to it.*
Deep Understanding	*Deep understanding is indicated when students grasp relatively complex relationships between the central concepts of a topic or discipline. They can produce new knowledge by discovering relationships, solving problems, constructing explanations and drawing conclusions.*
Substantive Conversation	*There is considerable interaction among students, and between teacher and students, about the ideas of a substantive topic. The interactions are reciprocal and promote shared understanding*
Knowledge as Problematic	*This involves an understanding of knowledge not as a fixed body of information, but rather as being constructed, and hence subject to political, social and cultural influences and implications*
Metalanguage	*Such instruction incorporates frequent discussion about talk and writing, about how written and spoken facts work, about specific technical vocabulary and words, about how sentences work or don't work (syntax, grammar).*

SUPPORTIVE CLASSROOM ENVIRONMENT	
Student Direction	*Students influence the specific activities or tasks they will do in a lesson or how they will undertake them.*
Social Support	*Social support is characterised by an atmosphere of mutual respect and support between teacher and students, and among students.*
Academic Engagement	*Students are engaged and on task. They show enthusiasm for their work by raising questions, contributing to group activities and helping peers*
Self-Regulation	*The direction of student behaviour is implicit and self-regulatory*
Explicit Quality Performance Criteria	*The criteria for judging the range of student performance is made explicit. Using tools such as rubrics.*
CONNECTEDNESS	
Knowledge Integration	*This occurs when explicit attempts are made to connect two or more sets of subject area knowledge.*
Background Knowledge	*Opportunities are provided for students to make connections between their own background knowledge and experience and the topics, skills and competencies they are studying and acquiring*
Connectedness to the World	*This describes the extent to which the lesson has value and meaning beyond the instructional context, making a connection to the wider social context within which students live.*
Problem-Based Curriculum	*Such curriculum is one in which students are presented with specific practical, real or hypothetical problems to solve. Problems are defined as having no single correct solution, requiring the construction of knowledge by the students and requiring sustained attention beyond a single lesson.*
RECOGNITION OF DIFFERENCE	
Cultural Knowledge	*A range of cultures, an acknowledged and given status. Cultures are valued when there is implicit appreciation of beliefs, languages, practices and ways of knowing.*
Group Identity	*Teaching practices build a sense of community and identity.*
Narrative	*The use of narrative in lessons involves an emphasis both in teaching and in student responses or personal stories, biographies, historical accounts and literary and cultural texts.*
Inclusivity	*Inclusive classroom practices intentionally acknowledge, support and incorporate the diversity of students' diverse backgrounds, experiences and abilities.*
Active Citizenship	*This element involves acknowledging that in a democratic society all individuals and groups have rights and responsibilities.*

The following sections discuss the four dimensions of Productive Pedagogies in turn.

2.5.1: Intellectual Quality

The Intellectual Quality dimension of the Productive Pedagogies model emphasises the importance of all students, regardless of their background and perceived academic abilities to be presented with intellectually challenging work (Mills, Goos, Keddie, Honan, Pendergast, & Gilbert, 2010; Newmann & Associates, 1996). As pointed above many students who can successfully perform routine, computational skills; find it difficult to solve problems requiring Intellectual Quality skills (Dossey, et al., 1988; McKnight et al., 1987).

Arnold (2003) suggested that promoting Intellectual Quality is important. It aspires to acquiring deep knowledge and deep understanding, to a view of knowledge as problematic rather than something to be transmitted in a static well-established format or routine. Teachers aiming for Intellectual Quality in mathematics classrooms always seek to promote substantive communication among their students in order to achieve their goals. They also focus their teaching in developing students' deep-understanding in worthwhile and meaningful contexts that will require them to use higher order thinking which goes beyond simple recall, recognition, and reproduction of knowledge to analysis, synthesis, evaluation, and production and construction of new ideas (Atweh, 2007).

Hargreaves (2003) argued that we now live in a knowledge society and mathematics teachers need to equip their students for life to fit into these knowledge societies. This would require teachers to encourage the development of students' creativity and ingenuity and to teach the students societal roles, norms, values and dispositions in order to create in them the sense of global responsibility that extends beyond the bounds of the knowledge economy. This further suggests that working to promote creativity and ingenuity among students during mathematics instructions will involve intellectually challenging classroom activities that will promote deep cognitive learning. This involves higher order thinking which is linked with particular understandings of knowledge as not fixed but socially produced and in the process the students learn the processes of creating new knowledge. Resnick (1987), however, noted that mathematics thinking skills resist precise forms of definition, and these thinking skills can be recognized when each occurs in a classroom setting.

Higher order thinking is described as the use of complex, non-algorithmic thinking to solve tasks in which there is no predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instruction, or a worked out example to the solution of the problem (Education Queensland, 2001). Here the student is thinking and generating his/her own algorithms and come up with his/her own solution to the problem (Resnick, 1987; Senk, Beckman & Thompson, 1997; Stein & Lane, 1996).

Lower-order thinking is often characterized by recall of information or the application of concepts or knowledge to familiar situations and contexts given by the mathematics teacher. Schmalz (1973) noted that mathematics tasks that require students to recall facts, perform simple operations, or solve familiar types of problems can be referred to as students' lower order thinking skills. This type of task does not require students to work outside what they are familiar with. Similarly, Senk, et al. (1997) in their own study described lower order thinking as solving tasks where the solution requires applying a well-known algorithm or procedure, often with no justification, explanation, or proof required by the student, and in a situation where only a single correct solution is possible.

Studies have shown that students in the traditional content-based learning environments exhibit lower achievement both on standardized tests and on project tests dealing with realistic situations than students who learn through a problem-based approach (Boaler, 1998). In contrast to the traditional classroom environments, studies have demonstrated that a problem-based learning environment provides students with opportunities to develop their abilities to adapt and change methods to fit new situations (Smith, 1998). Erickson (1999) suggested that students in problem-based learning environments typically have greater opportunity to learn mathematical processes associated with communication, representation, modelling and reasoning.

Resnick (1987) suggested that the problem-based approach contributes to the practical use of mathematics by helping students develop their own faculties and adapt them to the classroom approaches. This helps students transfer these adaptable approaches to new work environments when faced with career changes during their later working lifetime (NCTM, 1989). It suffices to say that mathematics teachers should focus their efforts on preparing their students to be good adaptive learners. This will assist their students perform effectively when unpredictable tasks and situations demand change (Resnick, 1987). In England, Cockcrift (1982) also advocated problem based approaches as means of developing mathematical thinking among students.

According to Webb (2002), interpreting and assigning depth-of-knowledge to both mathematics teachers and their students in mathematics teaching learning practice is very essential for students' learning. Mathematics teachers therefore could consider introducing students to more mathematically difficult concepts where suitable, and providing learning of mathematics relationships between facts and concepts which will not only widen students' views mathematically, but will also give these students opportunities to apply their knowledge to the world situations around them (Webb, 2002).

On deep understanding, Albert (2000) was of the view that when mathematics teachers make their students work collaboratively in a group they tend to talk about and make sense of the mathematics they are exploring and these students tend to express the concepts they are learning in their own words and ways. Regardless of the context in which mathematics teachers engage their students with mathematics, it is generally agreed that mathematics teachers who provide insight into developing mathematics understanding among students help develop to some extent their own understandings. These understandings are best built on students' personal experiences, intuitions and formal knowledge taught in the mathematics classroom. Similarly, Chinnapan (2006) was of the view that:

> *Mathematics teachers have invested considerable effort in exploring instructional strategies that would help learners to develop a better grasp of mathematical concepts. One stream of inquiry about teaching approaches has focused on teaching practices that aid in the construction of a powerful and meaningful understanding of mathematics and its utility. Developments in cognitive psychology and domain expertise have yielded significant lines of inquiry about what we mean by powerful understandings of mathematics students in mathematics. (p.182)*

On substantive conversation, Gallos (2003) was of the view that life is dialogical by its very nature, that is, to live means to engage into dialogue with other people around you; this dialogue includes to question, to listen, to answer, agree, and reject. Similarly, Clarke (2001) suggested that frequent communication among students is considered a key attribute for effective classroom instruction. Clarke went further to observe that students often sort out ideas by talking things through with the person sitting next to them. However, Gallos (2003) argued that talking things through does not work all the time, but when it does it seems to be an effective means of interaction during classroom instructions.

In classroom teaching, Corwin (1997) supported mathematical conversations and opined that mathematical knowledge is developed through conversations between individuals and that by talking; students would be able to clarify their ideas and also their doubts about mathematical issues. Frykholm and Pittmman (2001) observed that through students' mathematical conversations, knowledge of the mathematics concepts are deepened; this helps students generate questions during lessons, which encourages further dialogue. McClain, McGatha and Hodge (2000) observed that students' discussions support the development of mathematical arguments. This assists students to have the opportunity of explaining their justifications and developing their ways of reasoning to support their analysis.

The focus of what types of mathematics knowledge is essential for teaching mathematics has been the subject of numerous studies. Hayes et al. (2006), QSRLS (1999) and Atweh (2007) were of the view that presenting mathematics knowledge as problematic involves the understanding of knowledge not as a fixed body of information, but rather as being constructed and hence subject to political, social and cultural influences, in which multiple constructions, contrasting and potentially conflicting forms of knowledge are represented.

Metalanguage should be highly encouraged in mathematics as mathematics has its own unique language and if the teacher does not assist students to deal with this complexity, the students will continue to fail mathematics. In their study of mathematics language problems of Junior Secondary School students Gombe Metropolis, Bature and Igwe (2010) discovered that most students fail mathematics because they find it difficult to comprehend the meaning of most complex mathematical symbols, axioms, laws and theories. In some instances this involves the use of mathematics context-specific languages during classroom interaction and instructions. Alexander (1995) contended that such self-regulated verbal utterances not only offer evidence of, but indeed support cognitive development of students.

2.5.2: Connectedness

The idea of connectedness in mathematics classrooms goes beyond the link between mathematical concepts and procedures. The NCTM standard emphasized that if curriculum and instruction focus on mathematics as a discipline of connected ideas to the students, mathematics will be relevant to the students (NCTM, 2000). With regard to student learning, as teachers help students make connections and develop understanding of mathematical relationships the fabric of their mathematical proficiency becomes ever more flexible and sturdy. Similarly, when mathematics teaching is well connected, Banks (1993) was of the view that it will provide the opportunity for students to apply the discipline to real life situations and in their own perspectives. Bank suggested further that it is also well documented in the literature that effective teachers have general intention to make connections among mathematical concepts and procedures. They were of the view that this connection ranges from simple and superficial connections between individual pieces of knowledge to complex and underlying connections among different mathematical operations.

Helping students develop connections between various forms of mathematical knowledge, as well as between mathematics and real-life experience, is increasingly recognised as integral to effective mathematics instruction (Cooper & Dunne, 2000;

Education Queensland, 2002; Lubienski, 2000). The NCTM (2000) stated that mathematics instruction should enable students recognise and use connections among mathematical ideas and understand how such ideas are interconnected and build on one another to produce a coherent whole. Boaler and Humphreys (2005) were of the view that it is documented in the literature that effective teachers of mathematics have good and excellent intention to make mathematical connections among concepts. When reflected in teaching, this suggest that, connectedness prevents students learning from being boring.

Background knowledge of students may also include the knowledge of the community the student came from, the local knowledge, the personal experience, media and the popular cultural sources around the students. This is aimed at providing relevant or key background knowledge that might enhance students' understanding of mathematics materials being intended for learning during classroom instructions. To understand which mathematics integration is found between and among mathematics and other subjects is very important. Davison, Miller and Metheny (1995) identified two forms of integration: *discipline specific integration* which involves activities involving algebra and geometry in mathematics and *content specific integration* which involves choosing an existing curriculum objective from mathematics and one from another subject (Davison et al; 1995; Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006).

Another approach to integrating curriculum in mathematics and other subjects is through the use of real-life activities in the classroom. Davison et. al. (1995) were of the view that by conducting experiments, collecting data, analysing the data, and reporting results, students experience the processes of other subjects and perform the needed mathematics analysis on their data. What is important is that mathematical operations are performed for the purpose of answering the questions that are of concern to the students about the problem under investigation and, generally about the real world outside the mathematics classroom.

The perceptions of real-world mathematics are explained in numerous sources. Roper (1994) observed that *"Mathematics is widely perceived as 'useful' in the 'real world', in 'everyday life', in one's present or future career and in the study of other subjects" (p. 174).* Mayer (1995) visualized Connectedness as the degree to which newly established knowledge structures are connected with structures already existing in the learner's knowledge base. In support of this reasoning, a number of reports and studies emphasized the importance of real-world mathematics. The NCTM (1989) affirmed the importance of the application of mathematics and the need for students to be able to view mathematics as a "*practical useful subject, they must understand that it can be applied to a wide variety of real-world problems and phenomena" (p. 18).*

Shealy (1993) also believed that teachers needed to connect mathematics to real-world on applied situations, because mathematics students need to move from the real world to a conceptual model, they must have a strong understanding of the real world problem domain and the mathematical domain related to it. DeCorte et al. (1995) validated this by demonstrating that in general, mathematics teachers sometimes tend to exclude real-world mathematical knowledge and realistic considerations when confronted with the problematic versions of the mathematics problems. However, Atweh (2007) was of the view that:

> *high Connectedness provide students with the opportunities to make connections between their linguistic, cultural, world knowledge and experiences and the topics, skills and competencies at hand. (p.* 106*)*

Mathematics teachers, researchers and educators have all made concerted effort to define the problem-solving approach to classroom teaching. For example, Lester, Masingila, Mau, Lambdin, Pereira dos Santos, and Raymond (1994) were of the view that mathematics teachers who focus their teaching through problem-solving contexts and enquiry-oriented environments are characterised by the teacher who is "*helping students construct deep understanding of mathematical ideas and processes by engaging in doing mathematics: creating, conjecturing, exploring, testing, and verifying"* (p.154).

Problem-based learning reveals the extent to which students are engaged in solving intellectually challenging mathematics problems. Mathematics classroom teaching today has shifted its emphasis from teaching problem solving to teaching mathematics through problem solving (Lester, Stone, & Stelling, 1999). When using problem-based learning, Nasir, Hand, and Taylor (2008) suggested that teachers should help their students focus on solving mathematics problems within a real life situation, and also encourage their students to consider the situation in which the problem exists when trying to find a solution to it. Most researchers examining the problem-based curriculum focus on its uses within and outside the mathematics classroom, with the key features being the use of collaborative small group mathematics work, the use of real life mathematics problems and the use of a student-centred approach where the teacher serve as facilitator (Barrows, 1996).

2.5.3: Supportive Classroom Environment

There are many research studies in the literature that have clearly demonstrated the significant role of supportive learning environment to learning of mathematics (Anderman, 2002; Anderman, Eccles, Yoon, Roeser, Wigfield, & Blumenfeld, 2001; Fraser, 1994; Moos, 1979; Turner, Midgley, Meyer, Gheen, Anderman, Kang, & Patrick, 2002). Supportive Classroom Environment according to Hayes et al. (2006) is the dimension of Productive Pedagogies that is most often identified by teachers and students as an important aspect of good classroom practice. Learning mathematics in a socially supportive classroom environment is critical to all students; however, it must be stated here that this supportive classroom environment should also be intellectually demanding.

QSRLS (1999) pointed out that issues relating to classroom environment had been a case of concern to a very large numbers of educators and educational researchers. Such research ranged from the well-known research on effective classroom environment, to a multiple research studies on the classroom behaviour of students, and to more progressive concerns about the treatment teachers give to students according to race, gender and class. In arguing for the creation of a supportive mathematics classroom, Atweh (2007) suggested that students should be given a voice in the classroom in order to let them have some say over the direction of the mathematics classroom activities they are undertaking.

Mathematics engagement is represented by active involvement, commitment, and concentrated attention, in contrast to superficial participation, apathy, or lack of interest (Newmann et al., 1992). Newmann et al. viewed student engagement in mathematics academic work as the student's psychological investment in an effort directed toward learning, understanding, or mastering the mathematics knowledge, skills, or crafts that academic work is intended to promote. Mark (2000) synthesized the definitions of several researchers and defined mathematics engagement as a psychological process, specifically, the attention, interest, investment, and effort students expended in the work of learning. This definition included affective aspects of mathematics engagement as well as academic ones.

In explaining engagement with a participation-identification model, Finn (1993) showed that there was a strong linear association between students participation with academic achievement. In other words, the higher the participation level, the higher the achievement scores of students in mathematics. From their study, Newmann et al. (1992) argued that engagement encourages students to work harder, while Greenwood (1991) observed a strong association between students' engagement and achievement in mathematics.

Self-regulation is understood by social cognitive researchers as proactively initiated thoughts, feelings, and behaviours that are planned and cyclically adapted based on self-generated or performance feedback in order to attain personal mathematical goals (Zimmerman, 2000). Self-regulated learning is a cyclical process because personal, behavioural, and environmental factors are constantly changing and students need to use feedback from prior mathematics experiences to adjust their current efforts (Zimmerman, 2000, 2008).

Students develop self-regulation as they participate in multiple social and instructional environments. Self-regulation originates and develops within these contexts through the reciprocal interactions among students and with their teachers, as well as through the opportunities available (e.g., tasks, classmates, and family).

While the ultimate goal is self-regulation, socio-cultural researchers use terms such as “adaptive learning” or “co-regulation,” in order to stress the role of ongoing interactions between individuals and contexts in the development of self-regulated learning (McCaslin & Good, 1996; McCaslin & Hickey, 2001; Rohrkemper, 1989).

Therefore, in developing this positive and mutually supportive mathematics classroom relationship, the importance of breaking down the power imbalances between mathematics teachers and their students is particularly important, given that many mathematics students resist being overpowered and controlled by their mathematics teachers, hence creating an apprehensive mathematics classroom environment which works against effective classroom instructions (Mills et al., 2009). Similarly Mills (1997, 2001) suggested that many disengaged students feel angry at the formal structures of classrooms because such structures do not provide opportunities for them to express their feelings. These students often feel that teachers sometimes punished them unfairly because they don’t allow them defend their views.

Explicit criteria should be provided to students so that expectations are clear, and a classroom environment is created where students are prepared to take risks with their mathematics teaching and learning practice (Lingard et al., 2001). Therefore, explicit expectations of mathematics teachers have to be both related to mathematics students’ school work and their performances as being good citizens. High expectations are always associated with the best teachers, and any quality teaching and learning environment must be a socially supportive place characterised by collaboration, positive reinforcement and shared responsibility for goal-setting among the learners and teachers (Arnold, 2003).

There is a need to provide students with a supportive mathematics classroom environment, if they are to achieve anything meaningful during classroom instruction. The notion of good mathematics teachers includes teachers who are not only concerned about the academic achievement of their students but are also helping make their students being positive members of a democratic community through their influence in supporting students in the classroom (Mill & Goos, 2007). Caring must become more than charity or control in a mathematics classroom, this must however be build based on relationship in which students that are cared for most have dignity and a voice during classroom instructions (Hargreaves 2003; Mill & Goos, 2007).

To measure the degree to which mathematics classrooms demonstrate the Supportive Classroom Environment as an independent dimension of Productive Pedagogies, QSRLS (1999) were of the view that there should be the social support for students' achievement in the classroom and even outside the classroom setting; there should be high degree of students' demonstrable academic engagement in the classroom activities; there should be a high degree of students' independent self-regulated behaviour during classroom practice; there should be a high level of students' exercising some control over the learning activities in their classrooms and the degree to which explicit criteria for high quality performance in the classroom practice should be made public in the lesson.

2.5.4: Recognition of Difference

Recognition of Difference can be viewed as a theoretical and practical dimension of Productive Pedagogies which explains how to significantly and systematically improve both the classroom teaching and their mathematics achievement especially among students from scholastically disadvantaged socio-cultural backgrounds. In this Atweh (2007) states that

> *the objectives of this dimension is to make sure that students know and value a range of cultures, create positive human relationships, respect individuals and help to create a sense of community relationships within the class. (p.* 108)

The literature on democratic education consistently identified distinguishable qualities of democratic classrooms to include problem solving curriculum, inclusivity and rights, equal participation in decisions, and equal encouragement for success (Pearl & Knight, 1999). Lampert (2001) suggested that the citizenship goals of mathematics classrooms are very important, because all that is within the classroom society, irrespective of background, occupation, sex, gender, religion or social-cultural status should be able to actively participate within that classroom society. She went further to suggest that citizens cannot practice what they do not learn, it could also be said that students do not practice what they do not learn to practice, hence the school is a central place for the production of active citizens that are well informed.

These qualities do not define the curriculum but serve as the basis for classroom interactions and discussions of overriding issues and questions through the use of specific and integrated knowledge of content areas. Beyer (1996) and Pearl and Knight (1999) suggested four qualities, framed in terms of mathematics classroom instructions: First, students should be presented with a curriculum in mathematics that allows them to draw on their accumulated knowledge to solve problems important to their lives and society.

Second, students should be taught using approaches that provide a range of opportunities for accessing and processing mathematical ideas. Mathematics should be examined from multiple perspectives affirming the worth of diverse experiences and approaches in solving problems. Third, students should be able to use the mathematics classroom as a forum for open discussions of mathematical and social issues and ideas, because through such discussions students are able to create, clarify, and re-evaluate their ideas and understand the ideas of others. And finally, students should have access to materials that engage them actively in the learning of mathematics irrespective of their abilities. They should be encouraged equally as they develop the habits or mind to draw conclusions and critically evaluate implications from mathematical data for personal and social action.

Many students and teachers believe that mathematics is culturally free in its nature: that is, it is a discipline without cultural significance (D'Ambrosio, 2001, 2006). In fact, mathematics is thought of as the development of structures and systems of ideas involving number, pattern, logic, and spatial configuration. Davidson (1990) suggested that the interaction between native culture and mathematical ideas can be mutually reinforced by the development of culturally sensitive mathematical activities. This could help students see the relevance of mathematics in their culture and also help mathematics teachers use these connections to teach more mathematics. The examination of how mathematics arises and is used in different cultures could provide opportunities for students to gain deeper understanding of mathematics. To this end, mathematics teachers need to identify and embrace instructional strategies that value all students' backgrounds irrespective of culture or identity, both socially and culturally to ensure that students are successful during mathematics classrooms practice (Cobb & Hodge, 2002).

Valuing and working with different dimensions present in mathematics classrooms will enable students to become aware of the ways in which various factors including gender, race or ethnicity, age and socioeconomic status can affect their identities (Frankenstein, 1997, 2001; Gutstein, 2003, 2006). To a great extent the presence of this dimension in a classroom enables mathematics teachers to teach for democracy, that is, to provide students with skills and knowledge necessary for them to act as responsible members of a democratic mathematics classroom community (Mill & Goos, 2007). Similarly, Hayes et al. (2006) suggested that:

> *Pedagogical practice that reflects this dimension would involve providing students with knowledge about non-dominant ways, in terms of gender, ethnicity, race, sexualities and explicably valued diversity, ensuring that all students are included in the classroom activities through active participation employing a range of teaching styles and strategies. (p. 68)*

To study inclusionary participation of students in mathematics classroom, the mathematics teachers need to make mathematics application with socio-cultural strategies to observe classroom discussion and interactions among the members of the classroom community. Similarly, a mathematics classroom learning environment should be made to become a culture with common patterns of perceiving, believing, acting and evaluating mathematics classroom activities (Goodenough 1981; Rex, 2003).

Geertz (1973) suggested that mathematical language should be made to become a dominant medium through which the meaning of those patterns is built and evolves over time; while Rex (2003) stated that there should be an assumption that these common mathematical patterns should be constructed and held in place by social practices within the mathematics classroom community. This suggests that mathematics teachers are the primary sociocultural mediators of inclusive mathematics classrooms. Rex (2003) suggested that mathematics teachers have the role to mediate the processes of integrating students' background experiences and cultural knowledge into classroom curriculum and instructional activities during mathematics classroom instruction. He went further to state that this is essential for creating an inclusive mathematics classroom.

2.6: Summary

This chapter had reviewed the related literature that demonstrated the need for improving mathematics classroom instruction in Nigeria. Therefore from this review, a gap had been clearly identified in the literature that the Nigerian mathematics classroom needs reforms since the literature suggests that the traditional classroom teacher-centred teaching approach still prevails in the Nigerian classroom. This has not also helped students as there are indicators that their performance in mathematics has generated concern. The need for a change in this approach to give way to a more student-centred approach was also established.

The review indicated that the Nigerian mathematics classroom teachers maintained a traditional teacher controlled classroom system where instruction is dominated and dictated to the students with the teacher remains prevalent. However the review also suggested that for effective teaching, mathematics teachers need to shift their role of knowledge givers to a more relaxed role of facilitators of learning. The shifting of roles as identified from the study does not imply that the mathematics teachers' responsibility of being in control of the class is discountenance; it rather suggests that learning is best achieved when teachers view their students differently using the constructivist approach and other theoretical approaches to classroom instructions as reviewed in the literature.

Another area the literature reviewed centred on the Productive Pedagogies framework as means to assist teachers making this shift. In the review, the researcher highlights key factors that Productive Pedagogies could be used as a tool for improving and achieving quality classroom instructions. This was discussed based on the ideas of creating democratic access to powerful mathematics classroom instructions. Four of the key distinguishable characteristics that provide quality mathematics classroom instructions as highlighted in the literature on Productive Pedagogies are summarised below.

First, mathematics teachers should make effort to provide students with equal encouragement for success through access to difficult and challenging mathematics materials that will develop critical thinking, and the ability to engage themselves in creating, and constructing their own knowledge through collaborative engagement using their previous knowledge and background experiences. This will help the students to be actively involved in learning mathematics during classroom instructions. Second, mathematics teachers should be able to create classroom environments that promote equal participation in decisions that affect students' lives, so that students can use the classrooms as a forum for public discussion of their own ideas and that of other members of the classroom community.

Third, the mathematics teacher should be able to develop a problem solving curriculum that should develop students' ability to draw on their previous mathematical knowledge to solve real life related problems of personal and social relevance to the student and to the community (classroom) he/she belongs, even if such problems have no single approach to their solution. Finally, inclusivity and rights of students should be promoted by mathematics teachers irrespective of ability, socio-economic status, gender, race or religion; presenting mathematics from multiple perspectives that affirm the worth of individuals and groups from diverse backgrounds found in the mathematics classroom. It is therefore presumed that if this research is properly and painstakingly carried out; it might be a useful tool to deal with the classroom problems that had bedevilled the Nigerian mathematics classroom.

CHAPTER 3

THE METHODOLOGY

3.0: Introduction

This study aimed to investigates the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. In Chapter 1 of this study the researcher discussed the rationale for developing and introducing the framework to the Nigerian mathematics classroom. Five research aims were developed to guide this study. These aims involve investigating

1. The scaffolding needed by participating teachers to implement the Productive Pedagogies framework;
2. The changes in the participating teachers' classroom practice as a result of the implementation of Productive Pedagogies framework;
3. The participating teachers' reflections on the effect of Productive Pedagogies framework on their practice.
4. The perceptions of students on the effects of Productive Pedagogies framework on their engagement.
5. The challenges that participating teachers encountered while introducing Productive Pedagogies.

Chapter 2 of this study reviewed the related literature to demonstrate the rationale and present the theoretical framework of the study. The chapter reviewed the research done on the framework in order to identify the gap for further research. This chapter centres on the research methodological approach adopted in investigating the introduction of the Productive Pedagogies framework to the Nigerian mathematics classroom. The study was divided into two phases. Phase 1 examined the introduction of the Productive Pedagogies framework to the participating teachers and how they used the framework in their mathematics classroom instructions in a community of practice. Phase 2 investigates the progress made by the four participating teachers in their classroom teaching after graduation from the university.

In discussing this methodological approach, the following areas were discussed: first, the researcher discusses the design adopted for the study. Second, the researcher discusses the sampling procedures used to select the participants for the study. Third, the researcher describes the procedures followed in conducting the research or collecting data. Fourth, the researcher also describes the instruments adopted to collect data for the study. Fifth, the procedures used to analysis the data collected is also described by the researcher. And finally, ethical issues associated with this research are also discussed

3.1: The Design of the Study

The underlying purpose of educational research is the acquisition of new knowledge (Borg & Gall, 1989). Two major approaches had dominated educational research globally, i.e., quantitative and qualitative methods. Studies have indicated that the majority of past educational research approaches had traditionally adopted the quantitative approach to research (Borg & Gall, 1989). The scenario is not different in Nigeria. According to Bature (2009), in an unpublished master's thesis, more than

90% of postgraduate research projects conducted in mathematics education in the sampled universities adopted quantitative approaches.

As helpful as this approach has been in trying to identify classroom problems, it is believed that quantitative research does not provide in-depth approach to finding new knowledge about problems and issues that can lead to in-depth knowledge (Creswell, 1998). This is because not all educational problems or classroom problems could be resolved using a composition of a handful of variables that can be measured with numbers and analysed through statistical procedures (Creswell, 2005). Therefore, the qualitative approach to research could be adopted for in-depth investigation to such problems or phenomena.

Similarly, the concern of educators should not only be based on the "how" of an educational problem, there is also the need to look at the "why" and "what" of the education problem. This could only be determined by the adoption of a qualitative approach in the search for answers. It suffices to say here that qualitative and quantitative research studies are not the only research approaches educators could adopt in finding solutions to their classroom problems. There are many other approaches that could be adopted in research. This could be action research (Atweh, Christiansen & Dornan, 1998; Stringer, 1996), mixed methods (Bergman, 2008; Tashakkori, & Teddlie, 2008) and a host of other approaches (Plano Clark, 2005)

Perhaps before continuing the discussion on the methodological approach to this research it is needful to begin with the definitions of both approaches. Quantitative research, according to Creswell (1998), is the systematic inquiry into social or human problems *"based on testing a theory composed of variables, measured with numbers, and analysed with statistical procedures, in order to determine whether the* *predictive generalizations of the theory hold true" (p. 2).* While qualitative research is viewed *"as an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting" (pp. 1-2).*

Denzin and Lincoln (1994) defined qualitative research as multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. Qualitative research involves the use and collection of a variety of empirical materials in the form of case study, personal experience, looking introspectively, life story interviews, observations, historical events, interactions, and visual texts that describe routine and problematic moments and meaning in individuals' lives and or society. Creswell (2005) saw qualitative research as an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem.

Qualitative research places emphasis on understanding through looking closely at people's words, actions and records. In this type of research the researcher conducts the study in its natural setting, analyses words and actions of the participants, builds a complex and holistic picture of the data collected and reports detailed views of information collected in his research. In qualitative research, the researchers examine the patterns of meaning which emerge from the data and these are often presented in the participants' own words.

The task of the qualitative researcher is to find patterns within those words and to present those patterns for others to inspect while at the same time staying close to the construction of the world as the participants originally experienced it. The goal of a qualitative researcher is to discover patterns that emerge after close observation, careful documentation, and thoughtful analysis of the research data (Creswell, 2005). What can be discovered by qualitative research is not sweeping generalizations but contextual findings. This process of discovery is basic to philosophical underpinning of qualitative approach (Creswell, 2005).There are different ways qualitative research could be approached. Merriam et al. (2002) described these approaches using the following.

First, *basic interpretive qualitative approach*: This is a qualitative approach where an instructor is interested in how his/her students make meaning to situations or phenomena. It uses inductive strategies for collecting data from interviews, observations, or documentary analysis (e.g., students' written work). Analysis is of patterns or common themes and the outcome is a rich descriptive account that makes reference to the literature that helped frame the study.

Second, *Phenomenological approach*: this is a qualitative approach that aimed at finding the essence or structure of an experience by explaining how complex meanings are built out of simple units of inner experience, for example, the essence of being a participant in a particular program or the essence of understanding a subject. The method involves temporarily putting aside or "bracketing" personal attitudes and beliefs regarding the phenomenon, thereby heightening consciousness and allowing the researcher to intuit or see the phenomenon from the perspective of those who have experienced it. All collected data is laid out and treated as equal, clustered into themes, examined from multiple perspectives, and descriptions of the phenomena are constructed.

Third, *grounded theory approach:* This is a qualitative approach that is derives from data collected about theory that is "grounded" in the data. The researcher in this approach deals with specific situations like how students handle multiple responsibilities or what constitutes an effective lesson plan. The method involves comparing collected units of data against one another until categories, properties, and hypotheses that state relations between these categories and properties emerge. These hypotheses are tentative and suggestive, not tested in the study.

Fourth, *ethnographic study*: This is a qualitative approach that could be described as traditional in anthropology. This involves studying human society and culture. It is less a method of data collection and more the use of a socio-cultural lens through which the data are interpreted. Extensive fieldwork is usually required in order to give a cultural interpretation of the data and immersion in the culture is common, but a description of the culture (the beliefs, traditions, practices, and behaviours of a group of individuals) and an interpretation of the culture through the point of view of an insider to that culture are necessary components of the ethnographies.

Fifth, *narrative analysis*: this involves the use of stories or life narratives, first person accounts of experiences. These stories are used as data, taking the perspective of the storyteller, as opposed to the larger society, with the goal of extracting meaning from the text. The most common types of narrative analysis are psychological, biographical, and discourse analysis. The former involves analysing the story in terms of internal thoughts and motivations and the latter analyses the written text or spoken words for its component parts or patterns. Biographical analysis takes the individual's society and factors like gender and class into account.

Sixth, *critical qualitative approach:* this is a qualitative approach where the researcher aims are to reveal and critique the social, cultural, and psychological assumptions regarding present day contexts with the goal of empowering individuals and enabling change. It challenges current power distributions and the status quo, as opposed to merely revealing meaning. Research questions may address race, gender, and class influences, how current power structures may serve some groups' interests and oppress others, and how truth and knowledge are constructed. This analysis is critical for methods like participatory action research which uses such critique as the basis for collective action.

Seventh, *Postmodern approach:* this is a qualitative approach that challenges the form and categories of traditional qualitative analysis. The postmodern perspective involves questioning certainties and assumptions in the world including the nature of truth, the ability of research and science to discover this truth, and all generalizations and typologies. Three "crises" have resulted from these questions; whether the experience of another can be captured or whether it is created by the researcher, whether any study can be viewed as valid if traditional methodologies are flawed, and whether it is possible to institute any real change.

Eighth, *case studies* approach: this is a qualitative approach that involves a descriptive intensive analysis of an individual, unit, or phenomena selected for its typicality or uniqueness. Different methods could be used to conduct this analysis (like ethnography) but the focus is on the unit of analysis, like an individual student's experiences or a group of few students studied in-depth.

While no single methodology is encouraged, this research is characterized by the inclusion of a plurality of voices and interpretations, an awareness of exclusion and the politics involved the choice of perspectives, and sensitivity to the power of the author's voice and language usage. Therefore the methodological approach that was utilised in this research was, a "Qualitative Case Study". This is a research strategy, or an inquiry that investigates a phenomenon within its real-life situation in such a way that change can be sustained (Yin 1994; Stake 1995, 1998). Prominent researchers have viewed case study as a study which focuses on the analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods (Gillham 2001; Miles & Huberman 1994). Similarly, Barzelay (2007) and Gerring (2007) were of the view that case study could be a study carried out by a researcher, in which the single objective is to use the cases to understand larger or similar studies.

The researcher adopted a qualitative case study approach to this research to understand the real life experiences of four participating teachers who adopted the Productive Pedagogies framework in a community of practice to improve their classroom practice. A small number of participants were selected so the researcher could have a manageable size of data for effective observation and analysis. The researcher engaged in direct observation of the teachers' classroom teaching and used the teachers also in a community of practice to observe and critique one another practice. This helped the researcher to use the experiences of the participating teachers in their natural setting to find patterns and meaning on their understanding and implementation of the Productive Pedagogies framework.

In supporting this approach Atkinson and Hammersley (1994) suggested that using participant observation in a social research setting provides emphasis in exploring social settings instead of testing hypotheses about them. Similarly, working primarily with unstructured data with no pre-coding of categories prior to data collection, studying a small number of cases and analysis of data using interpretation of meanings in the form of verbal explanations with little or no quantification and statistical analysis presents a clearer picture of a study (Guba & Lincoln, 1981). Investigators in case study research spend many hours in the field, collecting extensive data, and labouring over field issues of trying to gain access to the respondents perspectives of the research data (Creswell, 1994). The researcher must engage in the complex, time-consuming process of data analysis. This includes the ambiguous task of sorting through large amounts of data and reducing them to a few themes or categories.

3.2: The Participants in the Study

The question of sampling often seems to receive less attention in methodological discussion than issues of data collection and methods to be adopted in analysing data. However, the principles of sample and sampling in qualitative research should also be seen as equally important (Miles & Huberman, 1994). Stake (1994) distinguished between what he termed intrinsic and collective casework. In intrinsic casework stake was of the view that it is the situation where the participants or samples chosen were not based on sampling. This is because a particular case is the focus of the research study. While the collective casework is where one or more cases are chosen from a number of possible alternatives in order to explore a research theme. Stake was also of the view that, if qualitative research requires cases to be chosen, then

> *Nothing is more important than making a proper selection of* [such] *cases. This is a sampling problem; even in intrinsic casework, there may be issues*

> *of selection and choice to be resolved with respect to within-case sampling. (p. 243)*

When reflecting on different positions of experts in qualitative research methods, it suffices to note that there is less agreement in the literature on qualitative sampling. This difference of perspective is particularly obvious in those researchers that espouse pure theoretical sampling or designed specifically to generate theory and those that are established in fieldwork (Glaser & Strauss, 1967). However, Miles and Huberman (1994) suggested that sampling strategies can be evaluated in terms of six different attributes: these attributes according to them are presented in pedagogical forms of checklist. The interpretation of Miles and Huberman (1994) presented these six attributes by Curtis, Gesler, Smith, and Washburn (2000) as is summarised below.

First, the sampling strategy should be relevant to the conceptual framework and the research aims addressed by the research. This strategy suggests that the researcher consider whether sampling is intended to provide participants in categories which are pertinent to a pre-existing conceptual framework for the research, or how far the choice of participants might affect the scope for developing the framework of the research or the phenomena under study. Second, the sample should be able to generate rich and quality information on the phenomena under study. Miles and Huberman (1994) suggested that "*intensive research depends on the collation of thick and quality description of the phenomena*" (p. 34).

Therefore, in selecting the research sample, it is important that such sample is capable of providing rich data on the phenomena under study. Third, the sample should produce believable descriptions or explanations in the sense of being true to real life. One aspect of the validity of qualitative research relates to whether it provides a really convincing account and explanation of what has been observed. This criterion may also raise issues of `reliability' of the sources of information, in the sense of whether they are complete, or are subject to important biases which could influence the type of explanation to be made (Curtis, et al. 2000).

Fourth, is the sample strategy ethical? Miles and Huberman (1994) and Curtis, et al. (2000) were of the view that the researcher may consider whether the method of selection permits informed consent. Whether there are benefits or risks associated with selection of participation in the study, and the ethical nature of the relationship between researcher and informants. Sixth, is the sampling plan feasible? Miles and Huberman (1994) encourage researchers to consider feasibility in terms of resource, costs of money and time. The practical issues of accessibility constitute finding out whether the sampling strategy is compatible with the researcher's work style. Curtis, et al. (2000) added that competencies of the researcher and also the subject (sample) may also be important for feasibility. In view of these criteria, the researcher adopted the following sampling techniques to select the participants for this study. Most specifically the sections below discuss first, the selection of the schools used for the research, second, the selection of participating teachers used in the study, and finally, the selections of the focus group students.

3.2.1: Selection of Schools

Three secondary schools were purposively selected in three states in Nigeria. In Phase 1, one school was selected. The selected school was based on convenient sampling techniques. The researcher initially approached four schools within Bauchi metropolis with the aim of using the schools for the purpose of this research, however all the schools declined. Their reasons were based on the fact that these teachers were student-teachers and allowing them to teach their students for the whole term might not be in the best interest of the students. However the last school approached consented but insisted that only Senior Secondary School 2 classes be used. In Phase 2 the researcher travelled to the schools that the participating teachers were teaching after their graduation. Only three of the original teachers were followed-up since the fourth teacher had a sick baby and her school was on strike.

Table 3.1: Sample Schools and Their Characteristics

S/N	*School*	*Location*	*Phase*	*Characteristics*
1	*School 1*	*Bauchi Metropolis, Bauchi State*	*1*	*The school is a Private school located in the south of Bauchi metropolis. The school runs Nursery, primary and secondary sessions.*
2	*School 2*	*Kafanchan, Kaduna State*	*2*	*This school is a missionary school, own by the Anglican church. Is located in the south of Kaduna State. It operates both missionary and full secondary school curriculum where strict Christian philosophical norms and values are taught*
3	*School 3*	*Bokos Plateau State*	*2*	*This is a mission school, own by the Apostolic church. Located at Plateau central senatorial districts. It operates the secondary school curriculum.*

3.2.2: Selection of Participating Teachers

The fifth year mathematics education students from the Science Education Program of a University in North Eastern Nigeria were the sample for the study. These teachers were in their fifth and final year in a teacher upgrading program and had resumed for their final contact session. They were not full time university students. They were enrolled in a part time degree program which is divided into five contact sessions comprising the equivalent of a full year of contact. The Science Education

Program through the School of Technology Education run this teacher upgrading program called Long Vacation Training (LVT) program for teachers. The program was organized with the aim of developing qualify teachers to meet the challenges of the shortage of teachers in Nigerian schools. The program was organized so that teachers will not have to leave there jobs to attend a full-time university program thereby creating more problems on the shortages of teachers in the Nigerian schools.

The program was planned to cover the period of twelve weeks of intensive lecturers and assessment between the months of July and September every year. This is to enabling the teachers cover the scheme or the syllabus of the regular university full-time course.

Part of the requirements for the award of the Bachelor of Technology in this university is a two unit course called "*final year research Project*" this project unit is however not completely residential for the part time students. The Part-time students (teachers) have the privilege of coming to the university to meet with their supervisor anytime in the year. The researcher explores this unit in a community of practice as means of data collection being a lecturer in the mathematics education unit of the program and had taught these students methods of teaching mathematics in their third year (Contact 3) before leaving for his PhD study.

The researcher took the following steps to select the participants for this study. First, the researcher visited the program and met 12 fifth year students standing outside the department. Then the researcher made his vision known to them (that is, the researcher discusses with the students he met, about the possibility of working with them on this research project). After explanation, about 8 of the fifth year students indicated willingness to be part of the research (4 mathematics education students, 2 physics education students and 2 biology education students). In the second step, the researcher chose the 4 mathematics education students and explained to the remaining students that he wanted to work with only the mathematics education students since the research is related to mathematics education.

The third step taken in the sampling of the teachers was to obtain permission from their undergraduate project supervisors since their work in this project would constitute their final year project work. The researcher met the supervisors of the 4 students and sought permission from them to work with their project students. The project supervisors of 3 of the 4 students willingly and verbally agreed to release their students for the project, while the fourth student was denied because the supervisor was interested in the work of the student and preferred to continue working with the student himself.

However, another supervisor willingly released one of the students to the researcher. The student was contacted and she happily and willingly joined the team. The four participating teachers were briefed on their role in the research, as they were to choose their own research topics, determine their research aims, instruments, generate their data, and analyse them, to use these results for their final year research project. This final year research project constitutes part of the requirement for the award of the Bachelor of Technology (Mathematics education). The researcher served as their supervisor and a facilitator to their research in order to obtained data for his own research. The participating teachers selected were given pseudonyms in this project report as shown in table 3.2 below.

Table 3.2: Participating Teachers and their Characteristics

S/N	*Name*	*Age*	*Qualifications/Teaching Experience*	*Year level taught*
1	*Jimmy*	*32*	*NCE (Maths/Geography) 5 years*	*SSS 2 and JSS 3*
2	*Jerry*	*34*	*NCE (Maths/Hausa) 7 years*	*SSS 2 and 3*
3	*Jackson*	*34*	*NCE (Maths/Computer) 7 year*	*SSS 2 and 3*
4	*Jennie*	*32*	*NCE (Maths/Computer) 7 year*	*Primary 5*

Note: The Nigerian education system at the secondary school level before the introduction of Universal Basic Education (UBE) was a six year education program broadly divided into two sections of junior secondary school (JSS) and senior secondary school (SSS). The year groups are defined as junior secondary School 1-3 (JSS 1-3) and senior secondary school 1-3 (SSS 1-3). This classification is equivalent to the year group concept that operates in Australian schools. The junior secondary school according to the National Policy on Education (FGN, 2004) had now been moved to the compulsory 9-years basic education program. It retained the classification of its year groups, (JSS 1-3).

3.2.3: Selection of the Focus Group Students

In Phase 1, 6 Senior Secondary School 2 students were selected for this study. The selection was based on those who indicated their willingness to participate in the research. The Vice Principal, after the approval of the school by the school management, personally went to the class and informed the students about the research project and hence asked for students who would be willing to participate in a focus group discussion with the researcher. The Vice Principal also informed the students that those volunteering must be those willing to talk about the classroom teaching of the teachers coming to teach them for the whole term. The class nominated 6 Senior Secondary School 2 science students to represent the class in the focus group discussion. The Vice Principal sought their consent verbally and further gave them the consent forms to get the signature of their parents before participating in the research. The parents gave their consent. Below are the volunteered Senior Secondary School 2 students who participated in the focus group discussions and their characteristics. The participating students selected were given pseudonyms in this project report.

Table 3.3: Focus Group Students and Their Characteristics

S/N	*Name*	*Age*	*Class*	*Characteristics*
1	*Janet*	*15*	*SS2 Science*	*Janet was a strong defender of gender equality between boys and girls. She also contested the school Senior Girl (Head Girl) in the Spirit of Active citizenship and was elected by both teachers and students.*
2	*Jane*	*15*	*SS2 Science*	*She commanded the respects of her colleagues during the research. She was calm, intelligent and cool looking. She contested the school head girl-ship with Janet and lost.*
3	*Julie*	*16*	*SS2 Science*	*Julie was very outspoken in defending her views. She never succumbed to cultural and gender (male) domination over females. She was the outgoing school Female Social Prefect.*
4	*Mike*	*16*	*SS2 Science*	*Mike though very quiet was very composed in defending his views. He was the School outgoing Social Prefect. He however contested the school Senior Prefect (Head boy) in the Spirit of Active citizenship and was elected by both teachers and students.*
5	*Micah*	*15*	*SS2 Science*	*He was a serious critique and supporter of Productive Pedagogies. In the defence of his view, he believed in details and wants to be convinced on whatever any other person is saying for or against Productive Pedagogies. He was one of the school outgoing prefects.*
6	*Michael*	*17*	*SS2 Science*	*He was very composed and always speaks with facts. In the defence of his view Michael will always come to focus group meetings with his notes. He was the outgoing School ICT Prefect.*

In Phase 2, 6 senior secondary 1 students were randomly selected to participate in casual interview with the researcher. The researcher intentionally selected three students each from the two classes taught in Kafanchan and had a question and answer session with the students after the classroom instruction with the teachers. Pseudonyms were also given to the students. Their ages ranges from 14 to 17 years old. These students were, Jamila, Jasmin, Jessica, Jamilu, James and Jones.

3.3: The Instruments

In this research, the researcher adopted a cyclic approach to collect data, in which there were three cycles spanning across 6 weeks in Phase 1 of the study. However, the researcher relied on some strategies in collecting data which included classroom observations made during the classroom teaching of the participating teacher, and the interviews. These were in the form of discussions, interactions and casual interviews. The planning and the reflection meetings, the focus group discussions and the casual interviews informed the aims of the research as stated in Section 3.1 above (these were discussed in details below). There were no special plans for casual interviews. The discussions were guided by following general questions particularly during the focus groups and the reflections meetings.

1. From your observations and rating of the classroom practice of your colleague using the Productive Pedagogies Classroom Observation Manual. Discussed the strength and weaknesses observed from the participating teachers according to the dimension chosen.

2. Are there possible suggestions that could be used to enhance the participating teachers teaching using the Productive Pedagogies framework?
3. To what extents did the participating teachers created opportunities for students' engagement in mathematics as observed during the cycle?
4. What are your views about the framework generally as regards achieving quality classroom instruction in the Nigerian classroom?

Each observed classroom teaching was discussed according to the dimension selected. The implementability of each dimension selected by the teacher was discussed in terms of strength and weakness and possible ways of improvement in the next cycle as stated above. Each participating teacher chose one dimension of Productive Pedagogies as a framework for reforming his/her classroom teaching and to use the same dimension as a research focus. For example, Jimmy selected Intellectual Quality, Jackson selected Connectedness, and Jerry selected, Supportive Classroom Environment while Jennie took the Recognition of Difference.

The Productive Pedagogies Classroom Observation Manual (Appendix 4) developed by the Queensland School Reformed Longitudinal Study commission by the Education Queensland (2001) was used as an observational tool during the classroom instruction of the participating teachers. The 24-page booklet contains explanations and examples of all 20 elements of the Productive Pedagogies along with a 5 point Likert scale. Table 3.4 shows one example of the standard criteria. (See Appendix 4 for the standards criteria for other elements).

Table 3.4: ***Standards Criteria for Knowledge As Problematic As Shown in the Original Booklet (Education Queensland, 2001)***

Are students critiquing and second-guessing texts, ideas and knowledge?				
1	*2*	*3*	*4*	*5*
No knowledge as problematic. All knowledge is presented in an uncritical fashion	*Some knowledge seen as problematic - but interpretations linked/reducible to given body of facts*	*Approximately half knowledge seen as problematic. Multiple interpretations recognised as variations on a stable theme*	*Explicit valuation of multiple interpretations and constructions of information, presented as having equal status, and being equally accommodated and accepted by others.*	*All knowledge as problematic. Knowledge is seen as socially constructed, with conflicting implications and social functions producing resolution and/or conflict.*

3.3.1: Classroom Observations

Classroom observation is an approach to professional learning that could be personal or collaborative. The observers must focus on what they are viewing depending on the objectives of the research (McConkey, 2002). Classroom observation is a process by which the researcher sits in on one or more classroom sessions to observe, tape record or video record the teachers' teaching practices and student actions during a particular research period. In this research there were three different forms of observations made to collect data for this study: first, the participating teachers' peer observations, secondly the students' observation and finally the researchers' observations.

The Participating Teachers' Peer Observations**:** On this type of observation the participating teachers observed one another for about six times during the research period using QSRLS Productive Pedagogies Classroom Observation Manual (Education Queensland, 2001). Other findings were also recorded in their researcher journal for discussion during the planning and reflection meetings. Peer observation according to Mott MacDonald Group (No date) helps build the participating teachers' skills and confidence in giving and receiving feedback within their teams. It also helps in supporting continuous improvement in the quality of teaching and learning among the collaborators (Bell, 2001; Ferren, 2001; Keig & Waggoner, 1995).

Peer observations are most effective when the participants approach it collaboratively. It serves as a means to benefit all the participants involved by creating an effective developmental approach to continuing professional development and the enhancement of teaching and learning (Keig & Waggoner, 1995). For example, for the one being observed, an observation can provide useful feedback that might not be revealed through the use of other methods of data collection. For the one observing, the experience can provide an opportunity to learn from seeing a fellow teacher in action. The HEFCE (2002) suggests that participation in formative peer observation of teaching could help improved the observers understanding of the teaching process. This will further increase the understanding of teaching actions and the level of collegiality of both the observed and the observer. In view of these decisions, the participating teachers engaged in 6 observations each, observing one another classroom instruction during the research. Discussions, dialogues, debates and suggestions were made during the planning and reflection meetings on the views of all the participating teachers on issues they observed.

***The Focus Group Students' Observations*:** The students constituted another observational team during the research. Even though they were members of the classes taught by the participating teachers, receiving their normal lessons, they were also involved in the observation of the classroom instructions of the participating teachers. They observed the participating teachers' classroom teaching in order to discuss during the focus group discussion. Their observation basically centred on what was their perception of the new classroom environment created by the participating teachers. Dalley-Trim (2007) in his study asserted that personal views of students on the characteristics and professional qualities of their teachers as well as the types of learning episodes with which they engaged in the class are very important.

***The Researcher's Observations*:** In Phase 1 most of the researchers' observations were not planned observations. In view of this, the researcher dropped in unannounced and observed the classes, writes the observations, and then arranged a reflection meeting and the focus group discussions with both the participating teachers and the focus group students for extensive discussions. However, the researcher made concerted effort to videotape and personally observed the classroom teaching of the participating teachers in the last classroom teaching of Phase 1 and the whole of Phase 2 of the research. This constitutes a total of 5 such classroom observations to each of the participating teachers (1 in Phase 1 and 4 in Phase 2).

3.3.2: Interviews

In conducting the interviews, the researcher adopted the following principles: First, the researcher acted as the facilitator of the discussions and the note taker with the research assistant who operated the recorder equipment to record the planning and reflection meetings and the focus group discussions with the students. Second, there was the decision of the time. Group discussions normally lasted for an hour and a half or more, though they were longer in some cases. The times for these interviews especially in Phase 1 of the research were planned between the researcher and the participants. For example, among the focus group students it was agreed to be the time that will not interrupt the students' classroom lessons, hence this was done during afternoon preps (students' study period in school) and weekends. There were three sessions of both reflective and focus group meetings with each of the sessions lasting for about five hours divided into two different sittings, except session two of the focus group students which were compressed to about three and a half hours because it was held in one of the students' homes during the weekend.

Third, there was the decision of the location. Group interview or meetings should be conducted in locations that are convenient and comfortable for participants, it should be locations that are quiet and have some degree of privacy. In this research the location was the computer room of the secondary school that was used for the study. Fourth, there was the invitation of the participants; before the date of each meeting, all the participants were invited to take part. The participants were always contacted and confirmed a day before the meeting to remind them of the time and location of the meeting and to also confirm their participation, despite agreeing and fixing the date of the next meeting at the previous meeting. Fifth, there was the group meeting guide. The discussion guide is an outline, prepared in advance for a specific set of respondents, which covers the topics and issues to be explored. The guide which contains the elements of the four dimensions of Productive Pedagogies was designed with the overall research aims in mind and was constructed to ensure that topics covered are relate to the research aims.

At the beginning of discussions, it was helpful to let participants know about some ways to make the group proceed smoothly and respectfully for all participants. Rules that helped establish good interviews during the research were recommended and adopted. For example it was agreed that only one person talks at a time, all others listened and commented at the end. There was also the need for confidentiality in what was discussed: what was shared in the room stays in the room. There was the need to hear everyone's ideas and opinions; there were no right or wrong answers to questions, it was just ideas, experiences and opinions, which were all valuable for this research. There was the need to hear all sides of an issue; both positive and negative issues were raised and discussed. And the males' and females' voices and ideas were equally represented and respected during the discussion.

In this research, 3 forms of interviews were conducted. The first interviews were the planning and reflections meetings held with the participating teachers. The second interviews were the focus group discussions held with the focus group students. And the third interviews were the casual interviews held with the participating teachers and some selected students. In each of the cases the researcher had direct contact with the participating teachers and or the focus group students either in groups or individually.

The Planning and Reflection Meetings: The concept of teacher reflection as a method for improving teaching can be traced back to John Dewey who established the importance of 'reflective thought' in educational contexts in general. While Dewey had been the traditional source for a philosophical rationale of the 'what' and 'why' of reflection in education, Rogers (2002) argued that there is no exact, systematic, or operational definition of reflection in educational contexts. Nevertheless, the importance of reflection in education in general has been undeniable, with Dewey (1933) defining it as

> *A special form of thinking that is active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that*

> *support it and the further conclusions to which it tends, constitutes reflective thought. (p. 9)*

Reflection is generally recognized as an important part of effective mathematics classroom teaching because it assists the mathematics teacher in becoming more aware of his/her views, which are subjected to critical analyses through discussions, dialogues, debates and criticism and, if possible, the teacher could restructure his or her views, approaches or methodology depending on the direction in which the reflective dialogue is led (Korthagen, 2001). In particular, reflective processes have had significant influences on mathematics teacher education (Nichols, Tippins, & Wieseman, 1997).

In this research the researcher adopted planning and reflection as a source of data collection. There were three of these reflections meetings with the participating teachers in each session. These were all video recoded. The researcher moderated the discussions using the elements and the dimensions of Productive Pedagogies as outlined in the Productive Pedagogies Classroom Observation Manual (appendix 4) to determine the level of the implementability of the framework in the classroom instruction of each of the participating teachers. The number of interviews, observations, planning and reflection meetings and focus groups discussions in Phases 1 & 2 are showed in Appendix 5.

***The Focus Groups*:** Focus groups are a form of group interview that capitalize on communication between research participants in order to generate data. Although group interviews are often used simply as a quick and convenient way to collect data from several people simultaneously, focus groups are forms of interviews that are based on group interactions. This means that instead of the researcher asking each person to respond to a question in turn, people were encouraged to talk to one another, ask questions, exchange anecdotes and critique each other's experiences and points of view (Kitzinger, 1994). The method is particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think but how they think and why they think that way.

The researcher adopted the focus group discussion sessions to determine the level of students engagement on Productive Pedagogies as could be seen in Appendix 7 generally the students discusses the effectiveness of the framework in the context of their engagement, however in some cases there were digressions to the effectiveness of the implementability of the framework generally and how it affects their engagement during the classroom teaching of the participating teachers.in this research there were also 3 focus group session which were video recorded. Some aspects of the discussions are shown in Appendix 7

Casual Interviews: Casual interviews in the context of this research are in-depth discussions or dialogues the researcher had with the participating teachers and some selected students individually and sometimes in groups. The researcher recorded their response in the Research Journal (Lofland & Lofland, 1995). This form of interview was not structured and hence does not follow a rigid form of question and answer sessions. It was rather conversational in nature and therefore sought to encourage free and open responses. There were also trade-offs between comprehensive coverage of topics and the in-depth exploration of more limited set of questions the researcher intended to explore. This implies that the researcher sometimes asked questions outside the schedule interview with the view to elicit further insight from the respondents’ perspectives.

Similarly, the casual interviews conducted by the researcher encouraged capturing the respondents' perceptions in their own words, a very desirable strategy in qualitative data collection. These provided opportunities for respondents to present meaningful and useful information in their experience and in their perspectives as related to the concept and applications of the Productive Pedagogies framework. Casual interviews conducted in this research were characterized by extensive probing and open-ended questions.

However, Lofland and Lofland (1995) was of the view that , the researcher in this type of interview sometimes prepares an interview guide that includes a list of questions or issues that are to be explored and suggested probes for following up on key areas. The guide helps the researcher to space the interview and makes interviewing more systematic and comprehensive. The dynamics of casual interviewing is similar to a guided conversational situation. This is because in casual interviews the researcher plays the role of an attentive listener, and sometimes shapes the process of the conversation into a familiar and comfortable form of effective engagement between the researcher and the respondent.

The quality of the information obtained during such conversations depends largely on the researchers' skills and personality presented during the interview (Patton, 1990). In contrast to a good conversation, however, a casual interview is not intended to be a two-way form of communication and sharing of ideas between the researcher and the respondent. The key to being a good interviewer is being a good listener and questioner. Similarly, tempting as it may be, it is not the role of the researcher during casual interviews to put forth his or her opinions, perceptions, or feelings. Researchers are meant to be trained individuals who are sensitive, empathetic, and able to establish and set up nonthreatening environments in which respondents feel comfortable to make their perspectives and views known to the researcher (Patton, 1990). Thorough training, including familiarization with the project and its aims, is important. Poor interviewing skills, poor phrasing of questions, or inadequate knowledge of the subject's culture or frame of reference may result in a collection that obtains little useful data (Patton, 1990).

In this research not all the casual interviews were videotaped and or recorded. There were situations where the researcher had contact with the participating teachers and the student as the need arose. At such times the researcher simply noted the comments raised by the participating teachers and the students in the Research Journal (which was kept by the researcher to record all observations throughout the research period). Such situations could pose possible further questions and dialogue between the researcher and the respondent, either for clarification or for in-depth presentation of issues raised. However, in Phase 2 of the research the researcher scheduled casual interview sessions with the participating teachers and conversations were recorded.

Table 3.5: Classroom Observations in Relation to Research Aims

Instrument	*Research aim*
Peer Observation	*1,2,3, and 5*
Students Observations	*1,2,3,4,5*
Researcher's observations.	*1,2,3,4,5*
Planning and Reflection Meetings	*1,2,3 and 5*
Focus Groups	*1,2,3,4,5*
Casual Interviews	*1,2,3,4,5*

3.4: Procedures

In this study, 2 Phases were designed for achieving the objectives of the study. Phase I of the study extended from September to December 2011 (first term of 2011/2012 session in Bauchi state Ministry of Education), while Phase 2 was for 5 weeks which extended from the first week of February to the second week of March 2013.

3.4.1: Phase 1

In preparation for the research, the researcher introduced the participants to the principles of the Productive Pedagogies framework through a two-day workshop. The purpose of the workshop was to help the participating teachers understand the basic ideas of Productive Pedagogies that they required to use to improve their teaching. Then the teachers used the knowledge they gathered during the workshop to teach mathematics for about 6 weeks in a community of practice.

The Cycles: There were three cycles of teaching and data collection. After each stage of classroom teaching the participating teachers collected their data through peer observations. The researcher held reflection meetings and focus group discussions with the participating teachers and the focus group students to review the cycles. Areas of difficulties were discussed and possible solutions proffered in preparation for the next circle.

The data collection in this Phase emerged from the observations of the participating teachers' classroom teaching, reflection meetings with the teachers and focus group discussions with 6 volunteer students and the use of casual interviews. The used of Research Journals to record the general observations made were also adopted. All the reflection and focus group meetings were videotaped. (See appendix 6) The

2011/2012 session in the state ministry of education where the research was held begins from the third week of September, 2011 to the first week of July, 2012. Each session is divided into 3 terms of 15 weeks each, except the first term which is usually 12 or 13 weeks. The first term of the 2011/2012 session started from the 19th of September 2011 to 9th of December 2011 making a total of 13 weeks. This was designed to cover up to 10 weeks of teaching, and revision and two weeks of examination while the last week is used for compilation of assessment results for the student. The research in this Phase 1 was designed to cover a period of 13 weeks, equivalent to the first term of the 2011/2012 session as provided in the state ministry of education calendar. However the research was only able to cover the 6 weeks of teaching and revision as shown in the table below.

Table 3.6: Research Schedule

Week	***Activities***
Weeks 1-3	*Collection of Manuals and other study materials by participating teachers and selection of research topic.*
Week 4	*Workshop.*
Week 5	*Cycle 1 implementation and observations*
Week 6	*Cycle 1 data collection, reflection and focus groups meetings*
Week 7	*Cycle 2 implementation and observations*
Week 8	*Cycle 2 data collection, reflection and focus group meetings*
Week 9	*Cycle 3 implementation and observations*
Week 10	*Cycle 3 data collection, reflection and focus group meetings*
Week 11 - 13	*Compilation of participating teachers' reports and presentation of research findings.*

The participating teachers were also conducting their own research in a community of practice. The data they collected during their observation are used for their final year research project as stated above. However, their comments and views based on their observation during the classroom teaching of their colleagues were raised and discussed during the planning and reflection meetings which constituted part of the data used for this research.

The Workshop: Education and training of research participant through a workshop plays an important role in helping them do well in any research project. The workshop in the context of this research was a two days short educational program designed to acquaint the participating teachers and the focus group students with the concept of Productive Pedagogies. It was also designed to brief the participants with the methodologies for data collection. This constituted how the reflection meetings could be held, that is, how they will use the Productive Pedagogies Classroom Observation Manual to assess the implementation of the framework. And to acquaint the focus group students with the concept of focus groups and how it could be implemented during the focus group meeting.

In order to make the workshop effective and participatory the researcher adopted the following strategies during the workshop. First, the researchers made the workshop participatory, that is, the participants were active, and to some extent influenced the direction of the workshop. They also had the opportunity of practicing the techniques and skills discussed during the workshop. Second, the researcher made the workshop informal, that is, there were a good deal of discussion, rather than the researcher only presenting material to the participants. Finally, the participants were provided with the workshop materials on Productive Pedagogies 4 days before the workshop. These workshop materials contained some suggested reading materials on Productive Pedagogies for their personal study. The workshop sessions in this research took 2 days as shown in the program in table 3.7

Table 3.7: Workshop Program

Date	Session 1	Session 2	Session3	Session4
14/10/11	*Introduction to Productive Pedagogies*	*Intellectual Quality*	*Supportive Classroom Environment*	*Discussion*
15/10/11	*Connectedness*	*Recognition of Difference*	*Research Methodology*	*Discursion*

It is important to note here that, the focus group students also participated in the workshop. This was done for two reasons. First, to acquaint the students with the principles of focus groups, how it is done and what is required of them during the focus group meetings. Second, since Productive Pedagogies is a new concept in the Nigerian classroom context, bringing the students to the workshop provided an opportunity for them to have the basic ideas of what it is and how important the concept is to their classroom instruction. The ideas the garnered during the workshop provided a springboard for discussion on the classroom instruction of the participating teachers during the focus group discussions.

3.4.2: Phase 2

Phase 2 of this study was for a period of five weeks. This took place between the first week of February and the second week of March 2013. The rationale for Phase 2 was basically for follow-up on the participating teachers. The participating teachers had graduated and resumed work in their various places of work. Therefore the researcher went to their various schools to further observe their progress on the implementation of the Productive Pedagogies framework. Not all the four participating teachers used in Phase 1 were used in Phase 2 of the study.

One of the participating teachers in Phase 1 was not available in Phase 2. Her school was closed down due to the state teachers' strike. Each of the participating teachers was observed in the classroom four times. The researcher interacted with the participating teachers through what is called casual interviews after the first observation. Informal discussions continued all through the five weeks which also constituted data for the study. The purpose for these observations was to investigate the participating teachers' ability to apply the Productive Pedagogies framework in their classroom teaching.

3.5: Data Analysis

This section constitutes the methodological approach to the analysis of data collected in this research. Analysing qualitative research data could be described as organising what the researcher saw, heard and read during the research period so as to make sense of what was learned. In this research the grounded theory approach was adopted to analyse the data generated.

Grounded theory was adopted because it possesses the power of allowing data to speak for itself. Bryman (2004) described the grounded theory method as developed by Glaser and Strauss (1967) as a systematic approach to data analysis, and as the most influential general strategy for conducting qualitative data analysis. The aim of this process is to assemble or reconstruct the data into meaningful or comprehensible fashion in which Charmaz (2006) suggested that the disassembling and reassembling of data occurs through a coding process. Similarly Trochin (2006) was of the view that the purpose of grounded theory is to develop theory about phenomena of interest. However, this is not just abstract theorizing but rather it is grounded or rooted in intensive classroom observation.

Grounded theory is believed to be a complex iterative process because the researcher begins with the raising of generative questions which help to guide the research which are not intended to be either static or confining. As the research develops, other core theoretical concepts are sometimes identified and tentative linkages are developed between the theoretical core concepts and the data (Miles & Huberman, 1994; Trochin, 2006). This early Phase of the research tends to be very open and can take months. As the research progresses the researcher tends to be more engaged in verification and summarising with the effort tending to evolve towards the central core category.

In developing a grounded theory approach to data analysis, Trochin (2006) suggested that the researcher pays attention to three key analytic strategies which are integrative-diagrams, memoing, and coding. These three strategies were also adopted by the researcher during this study. The first key strategy used in grounded theory as suggested by Trochin (2006) talks of diagrams as instruments to be used to pull all the details together to help make sense of the data with respect to the emerging theory. The diagrams can be any form of graphic that is useful at that point in theory development. They might be concept maps or directed graphs or even simple cartoons that can act as summarizing devices. This integrative work is best done in group sessions when participants are able to interact and share ideas to increase insight. The researcher however used a tabular format to describe the events and comments made by the research participants.

Table 3.8: Sample Codes

	Respondent	Comments	Coding
1	*Jennie*	*There was also a lesser application of Productive Pedagogies principles in her classroom approach. The lesson was mostly teacher-centred.*	*Poor application of PP concept*
2	*Moderator*	*What do you mean? Can you explain further?*	
3	*Jennie*	*He did not really make application of the elements of Intellectual Quality. His teaching was mostly teacher- centred as he was doing most of the talking.*	*Poor application of PP concept*

Another key strategy for grounded theory in qualitative data analysis as described by Trochin (2006) was the use of memoing. Memos are the theorizing write-up of ideas about codes and their relationships (Glaser, 1998). Glaser was also of the view that data collection, analysis and memoing are ongoing, and overlap. Similarly, Glaser was of the view that memoing should take precedence, because it is the actual write-up of what is emerging from the data and the analysis. Data is always available, and can be analysed at any time. Ideas are fragile. They should be written down at the earliest possible time.

While writing memos, think and write theoretically, in a "stream of consciousness" fashion, with no concerns about grammar, spelling, and such. At this time, the researcher might think of memoing extensive marginal notes and comments. Again, early in the process these memos tend to be very open while later on they tend to increasingly focus on the core concept of the research. In this research memos were basically used during the casual interviews with both the teachers and the focus group students. It was sometimes reflected and used in the course of classroom observations of the participating teachers' teaching or during the personal interaction with the participating teachers and or the students.

The third and the final strategy suggested by Trochin (2006) and used in this research was the concept of coding; this is a process developed for categorizing qualitative data and for describing the implications and details of these categories. This process involves the researcher as the main actor in the research process. The researcher uses the data collected during coding to intervene, manipulate, act, conceptualize, and use specific techniques to generate or develop the theory that is intended to be developed for the success of the research (Walker & Myrick, 2006). At the operational level, Glaser (1978) was of the view that coding strategies in analysing qualitative data appear rather simple, quite focused and more in keeping with the original version of grounded theory. Glaser described the code as *"The essential relationship between data and theory" (p. 55)* while describing coding as a process that,

> *Gets the analyst off the empirical level by fracturing the data, then conceptually grouping it into codes that then become the theory which explains what is happening in the data…? (p. 55)*

Glaser divided the coding process into two procedures: substantive and theoretical coding. Walker and Myrick (2006) described substantive coding as consisting of two sub-Phases, which according to them involves open and selective coding, and is concerned with producing categories and their properties. While according to Walker and Myrick (2006) theoretical coding occurs at the conceptual level, which involved the weaving of the substantive codes together into a hypothesis and or theory. Glaser (1992) viewed it as "*Conceptualizing data by constant comparison of incident with incident, and incident with concept" (p. 38).*

Glaser was also of the view that coding involves two simple analytic procedures aimed at creating categories and their properties. In the first procedure, the analyst makes comparisons of incident to incident to generate categories and then compares new incidents with the categories. The second procedure requires the analyst to examine the data through the use of neutral questions such as, what category does this incident indicate (Glaser, 1978). Walker and Myrick (2006) were of the view that these two procedures should be used together with the memos to document the analyst's ideas as the coding proceeds, and the theoretical sorting, which organizes the data and the memos into themes. Glaser (1992) as reported in Walker and Myrick (2006) stated that

> *Using the constant comparison method gets the analyst to the desired conceptual power quickly, with ease and joy. Categories emerge upon comparison and properties emerge upon more comparison. And that is all there is to it. (p. 42)*

Therefore, the researcher used the codes in this research to summarize, synthesize, and sort observations made on data, which became the fundamental means of analysing the data collected in the study. Similarly, the researcher used the codes to pull together and categorize a series of discrete events, statements and observations which were identified in the data and made relevant comments on them. Examples of some of the codes used in this research are summarised in table 3.9

Table 3.9: Samples of Codes

	Code	***Definition***
1	*Engagement*	*Referred to students' involvement in classroom instructions.*
2	*Carry along*	*Referred to students' assisted and helped the low achievers during the classroom teaching.*
3	*Left behind*	*Referred to the situation where students with learning disabilities were neglected;*
4	*Domineering*	*Referred to the situation where the mathematics teachers' discontented students' views during classroom instructions*
5	*Monopoly of knowledge*	*Referred to a classroom where the teachers' views and ideas override any other ideas of the students. In this situation the teacher is believed to be all knowing.*

The researcher divided, separated, or disassembled all the research materials into pieces, parts, elements, or units, with information broken down into manageable pieces. The researcher sorted and sifted through these materials, searching for types, classes, sequences, processes, patterns or wholes, and therefore gave these sorted out materials codes. This was done by reading through the data generated many times to identify relevant issues and give them names.

The researcher examined the materials collected with the aim of making some type of sense out of each collection; he looked for patterns and relationships both within and across the collections, and made general comments on the materials collected in relation to the research aims. The researcher compared and contrasted each of the themes noticed in order to discover similarities and differences, build typologies, or find sequences and patterns from the materials collected in order to answer the research aims postulated.

3.6 Quality of the Data Collected

Within the qualitative research paradigm, there are four different strategies that researchers adopted as a means for judging the trustworthiness of a research data. They are transferability, confirmability, credibility, and dependability (Lincoln & Guba, 1985). Three of these strategies are relevant to this research and are discussed below.

3.6.1: Credibility

Credibility is the qualitative counterpart of quantitative internal validity (Lincoln & Guba, 1985). It applies to activities that make it more likely that credible findings and interpretations would be produced from the data. Activities that establish credibility are prolonged engagement, persistent observation, and member checking. The purpose of prolonged engagement is to keep the researcher open to the multiple influences that affect the actors in the study (Lincoln & Guba, 1985). This research reported here lasted for a period of 15 weeks (10 weeks in Phase 1 and 5 weeks in Phase 2). In this research, the researcher was part of the data collection, that is, he was directly involved in the training, observing and working with the participating teachers throughout the research period.

The frequent visit to participating teachers' classrooms during their mathematics classroom teaching and observation satisfies the conditions for persistent observations. The researcher met with the participant frequently to discuss with the teachers and the focus group students sharing with them the data collected and asked further questions that were necessary during the analysis to clarify some issues raised by the participating teachers. The researcher and the participants were allowed the opportunity to respond to notes taken during the observations; these were discussed and or responded to during the reflection meetings. They also had the opportunity to confirm or adjust the interpretations made by other members based on their group discussion. The videotapes were used to help the researcher to recall events described in field notes should there be any doubt about anything written down in the journal.

3.6.2: Transferability

Transferability is the qualitative counterpart of quantitative external validity (Lincoln & Guba, 1985). Most traditional researchers view applicability of research findings in terms of generalizability and address the issue raised in their research focusing on those aspects of the inquiry that do not shift (Del Siegle, No date, Denscombe, 1998).

In naturalistic inquiry such as this research, no true generalization is really possible because, all observations are defined based on specific contextual activities that occurred in the study (Firestone, 1993; Gomm, Hammersley, & Foster, 2000). The naturalistic researcher does not maintain that knowledge gained from one context will have relevance for other contexts or for the same context in another time frame (Lincoln & Guba, 1985). In naturalistic study the obligation for demonstrating transferability belongs to those who would apply it to the receiving context (the reader of the study) (Bassey, 1981; Siegle (no date).

However, transferability is the criterion used to describe a context in sufficient detail to enable the reader to reach his or her own conclusion about whether transfer is a possibility. Although generalizability usually applies only to certain types of quantitative methods, transferability can apply in varying degrees to most types of research (Bassey, 1981). Unlike generalizability, transferability does not involve broad claims, but invites readers of research to make connections between elements of a study and their own experience (Bassey, 1981; Stake, 1994).

Del Siegle (no date) in his article Trustworthiness online suggested two strategies for achieving transferability in a qualitative research; that is the "*Thick description*" of the data collected and the used of "*Purposive sampling techniques*" in selecting the participants for the research. On thick description Siegle (no date) said transferability in a naturalistic study depends on similarities between sending and receiving contexts, the researcher collects sufficiently detailed descriptions of data in context and reports them with sufficient detail and precision to allow judgments about transferability to be made by the reader. While *on purposive sampling* Siegle contrasted random sampling and purposive sampling and was of the view that random sampling is usually used in traditional research to gain a representative picture through aggregated qualities, while naturalistic research purposive sampling is used to seeks to maximize the range of specific information that can be obtained from and about that context by purposively selecting locations and participants that meets up the desire objectives of the research (Denscombe,1998; Firestone, 1993 & Gomm, Hammersley, & Foster, 2000). Therefore, the researcher in this study adopted the *"thick description"* of the context and "*purposive sampling techniques"* for data collection to portray the detailed picture necessary for the reader to be able to draw his or her own conclusions regarding the transferability of the results to other situations (Geertz, 1973).

3.6.3: Confirmability

Confirmability is the qualitative counterpart of quantitative objectivity (Lincoln & Guba, 1985). This applies to the extent that the data collected and interpreted accurately reflect the views and opinions of the participants rather than the researcher's biases. In addition to the use of member checking as previously described above, the researcher kept an audit trail of the data collected to establish confirmability. An audit trail is based on keeping careful accounting of all the raw data collected during the study. In this research the researcher kept all original videotapes and research journal documents. A uniform system of coding that identifies each piece of data allowed interested readers to identify the source of quotes, interpretations, and research findings.

3.7: Ethical Issues

The ethical issues in this research were treated with utmost importance. Therefore the following ethical issues were upheld. Before the data collections began, the researcher obtained the candidacy approval and the ethical clearance (SMEC-25-11) on the 14th April 2011 from the Curtin university ethics clearance committee as shown in the appendix 1. Other ethical issues obtained for this research included the following:

3.7.1: Researcher-Participant Relationship

The unequal power relationship between the participating teachers and the researcher was taken into consideration in this research. Since the research was centred on the community of practice where the participants were also researchers, effective researcher-participant relationship was taken very seriously. This was done to ensure a more equitable relationship. A relationship of negotiation and trust was also established and maintained through the channels of informed consent and open communication. The participants studied the consent forms before responding in writing to the researcher on their willingness to participate in the research. The mutual relationship that existed between the researcher and the participating teachers was the manifestation of a true open and mutually trusting relationship. There was no fear in commenting on the weaknesses and strength of one another throughout the research period.

3.7.2: Informed Consent

All the participants in this study were provided with information about the nature and methodology of the research, its purpose, any risks and benefits, possible outcomes of the research, and the exercise of a voluntary choice to participate was also clearly mentioned to the participants of the research. Specifically, they were made to be aware that they were free to withdraw from the research at any time, without prejudice or negative consequences (Appendix 3). All the participants were provided with information sheets and consent forms containing this information (Appendices 3). Any observation of classes during their practicum was done with a written permission from the school concerned and the co-operating participating teachers.

3.7.3: Consideration

During the data collection, the participants (the participating teachers and the students) experienced minimum disruption to their normal study. Observations were spread across the term and took place during the participating teachers' classroom teaching. Focus group discussions were conducted outside school lesson periods to avoid students missing any lessons. The university where the participating teachers were final year students was on strike during the greater part of the research, so the participating teachers stayed back to continue their research.

3.7.4: Anonymity and Confidentiality

All the participants were guaranteed confidentiality and anonymity. Observation schedules had to be completed both before and after the program of study, ensuring confidentiality. Anonymity in the final thesis and any publications that may result from the study were achieved through name changes. Access to data gathered during the research will only be available to the researcher and the supervisor.

3.7.5: Acknowledgment

The participants were given the choice as to whether they wished to be acknowledged as having taken part in the research in the final work. However they were of the view that pseudonyms are more appropriate to be used instead of their actual names. The participating teachers used the data they generated to write their undergraduate research projects.

3.7.6: Data Storage

Any electronic data collected during the study were stored on computer protected by passwords. Any paper formats were also stored in a locked filing cabinet. Only the supervisor and the researcher had access to the data. All electronic and paper format data produced were stored in a safe and secure location in the Science and Mathematics Education Centre, Curtin University for a period of 5 years after the publication of thesis.

3.8: Summary

This chapter considered the methodological approach to the study. The chapter was divided into 7 sections. In Section 3.1 the researcher discussed the design of the study. The researcher started by describing the differences between the qualitative and quantitative research designs from literature before defining the qualitative approach to research. Different qualitative approaches to research in education were discussed. These included Basic interpretive qualitative approach, Phenomenological approach, grounded theory approach, ethnographic study, narrative analysis, critical qualitative approach, postmodern approach and case studies approach. The researcher however adopted the case study approach to his argument in Section 3.1. The study was designed to be in 2 Phases. In Phase 1 the researcher introduced the framework to the Participating teachers and to the focus group students. Phase 2 was basically a follow up to the Phase 1.

In Section 3.2 the researcher discussed the procedure adapted to the selection of the participants and their characteristics. In that section, 4 teachers and 6 focus group students were selected using purposive sampling technique for Phase 1. In Phase 2, 3 teachers and 6 students were also selected for the study. Two major sources of data were discussed in Section 3.3. First, the researcher used observations as a means of data collection. These included peer observations by the teachers, the focus group students' observations and the researcher observations. Second, the researcher also uses interviews as another source for data collection. This includes planning and reflection meetings, focus groups, and casual interviews.

Section 3.3 discussed the procedures for data collection. This included the workshops which were organized for both the teachers and the students. Similarly, the research was conceived in Phase 1 to be in 3 cycles where there were classroom observations and reflections and planning meetings with the participating teachers and the focus group students after every cycle. Phase 2 was conceived to be basically the observations of the classroom instruction of the participating teachers with some casual interviews with both teachers and some selected students. Section 3.4 constitutes the procedure for data analysis where the section described the approaches adopted by the researcher to analyse the data. In that section the researcher discusses the grounded theory approach to data analysis as the selected approached to data analysis. In Section 3.5 the researcher discussed the credibility, transferability and confirmability of the data collected, while Sections 3.6 and 3.7 talked about the ethical issues relating to the research.

CHAPTER 4

DATA ANALYSIS 1: SCAFFOLDING

4.0: Introduction

This study aimed to investigates the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. Five research aims were developed to guide this study. These involve investigating:

1. the scaffolding needed by participating teachers to implement the Productive Pedagogies framework;
2. the changes in classroom practice as a result of the participating teachers' implementation of the Productive Pedagogies framework;
3. the participating teachers' reflections on the effect of the Productive Pedagogies framework on their practice.
4. the perceptions of students on the effects of the Productive Pedagogies framework on their engagement; and
5. the challenges that participating teachers encountered while introducing Productive Pedagogies.

In designing the study, the main focus was on a group of teachers attempting to improve their teaching using the Productive Pedagogies framework. However, a complete picture of the resulting changes in the teachers' classroom instruction was not possible without taking into account the scaffolding given to the participating teachers and the students' voices and perspectives on the resulting changes in their classroom instruction. These teachers (as stated in Chapter 3) were final year part time students in a university in the north eastern Nigeria, conducting their final year research project (a compulsory unit for the final year students in the university). The researcher served as their supervisor as indicated in Chapter 3. Each participating teacher took one dimension of Productive Pedagogies in a community of practice to improve his classroom teaching and to also conduct his/her final year research project.

Their research projects focused on the following. Jimmy worked on *"the use of Intellectual Quality in reforming secondary school mathematics classroom practice*. Jerry research project focussed on *"Reforming secondary school mathematics classroom practices through effective Supportive Classroom Environment*. Jackson worked on "*Improving Secondary School mathematics classroom teaching through connectedness*." And finally, Jennie worked on *"The role of Recognition of Difference in Reforming Secondary School Mathematics classroom teaching*."

The analysis in this research is discussed in 3 chapters. Chapter 4 constitutes the scaffolding needed by the participating teachers to implement Productive Pedagogies framework (research aim 1). Chapter 5 discusses the process of implementation, reflection and challenges encountered by the participating teachers while implementing the Productive Pedagogies (research aims 2, 3 and 5). Finally, Chapter 6 constitutes the perceptions of students on the effectiveness of the framework in relation to their classroom engagement (research aim 4).

This chapter addresses the first research aim by considering the scaffolding needed by the participating teachers to develop an understanding of how to implement the Productive Pedagogies framework. The researcher discusses this scaffolding in four major parts. First, reasons for adopting scaffolding as a tool in this research are elaborated. Second, the researcher considers how the Productive Pedagogies framework was introduced to the participating teachers. Third, the researcher discusses the methods employed to identify areas where the participating teachers needed scaffolding. Fourth, the researcher discusses some specific areas of scaffolding provided to the participating teachers.

4.1: Rationale and Means of Scaffolding

Scaffolding used in this research was viewed as temporary support structures put in place to assist the participating teachers in understanding the concept and principles of Productive Pedagogies and how to use them to achieve quality teaching. In particular, scaffolding consisted of conceptual, material and linguistic tools used to support participating teachers'- in their understanding and implementing of the Productive Pedagogies.

The rationale behind the scaffolding in this research was to provide the participating teachers with information that will help link their old knowledge (previous experiences and assumptions about teaching) with their new knowledge (Productive Pedagogies). Because the Productive Pedagogies framework was a new concept for the participating teachers and in the Nigerian classroom, a two days' workshop was not enough for the participating teachers to learn all the principles and practices of Productive Pedagogies. Therefore the rationale for the scaffolding was to provide ongoing help and assistance to the participating teachers on how to use the principles of Productive Pedagogies to improve their practice.

Similarly, the scaffolding provided in this research was aimed at clarifying the purposes of the research. For example, the researcher explained the purpose of the research to the participating teachers and why this is important to them. When the participating teachers were aware of the direction of the research, choices were made on whether to proceed with the research or to withdraw from it. Similarly, when the participating teachers understood their role, they gave their best to the success of the research; it also made them inquisitive in their search for new knowledge.

The participating teachers achieved their search for new knowledge through constant dialogue, discussions, debates, criticising one another's thoughts and asking questions in order to achieve not just quality classroom teaching but better results in their undergraduate research project. Finally, scaffolding provided in this research was aimed at reducing uncertainty, disappointment and to avoid confusion on areas that might prove difficult for the participating teachers. This was achieved by identifying anticipated areas of challenge at each stage of the research and possible solutions were raised and discussed, negotiated and dialogued.

The researcher employed four methods to provide scaffolding to the participating teachers. First, the researcher made available to the participating teachers some printed materials such as literature and photocopies of articles needed for their study on the content of Productive Pedagogies and how it could be implemented. Secondly, the researcher planned for discussions, dialogues and interaction with the participating teachers not only during the reflection meetings but on one-to-one basis as required. Thirdly, the researcher also created opportunities for the participating teachers to discuss and dialogue with colleagues on their understanding of the language of Productive Pedagogies. For example, there was a reflection meeting and other meetings held either between the participating teachers or with the facilitator.

Finally, peer observation tools were provided. The QSRLS Productive Pedagogies Classroom Observation Manual (Education Queensland, 2001) was provided to the participating teachers to observe and rate the practice of their colleagues in the community of practice. The teachers applied the information collected using the manual to make necessary comments, suggestions and criticisms to help improve their own practices and those of their colleagues. The next section discusses how the researcher introduced Productive Pedagogies to the participating teachers.

4.2: Introducing Productive Pedagogies

While the workshop with the participating teachers at the start of the project was the main means of introducing the Productive Pedagogies framework to the participating teachers, the workshop activities were built on three forms of pre-workshop experiences and activities. First, the participating teachers were practicing teachers with limited preservice training and various numbers of years of teaching experience. Therefore, they did not approach the workshop with a total ignorance of at least some of the languages of Productive Pedagogies framework. They also had classroom experiences that the researcher used to build upon.

Secondly, when trying to recruit these participating teachers, the researcher briefed them on the aims of the project and their role in the research. In the process, they were introduced to the framework in general terms. Thirdly, before the workshop started the selected participating teachers were given reading materials related to the Productive Pedagogies framework.

In the next section, the researcher discusses issues relating to the teaching practices of the participating teachers and the classroom teaching and learning problems identified by the participating teachers before the research commenced.

4.2.1: Focus on Teaching Practices

The introduction of the Productive Pedagogies framework in the two-day workshop occurred through two preliminary activities designed to focus the teachers' thinking on the common ways of teaching in the classroom. Mathematics teachers do not often problematize teaching directly. They assume that there is one way to teach mathematics. They often lack the language to articulate their teaching methods. Since Productive Pedagogies is a language to describe teaching, the researcher reasoned that a good way to start talking about Productive Pedagogies would be to start by talking about teaching directly. The researcher therefore asked the participating teachers to identify methods they used in their classroom to teach mathematics to their students. Being practicing teachers this was not a challenge for them and they mentioned a range of methods and or teaching strategies that they use.

From this discussion, it became clear that the teachers have mainly used what can be called the traditional mathematics classroom teaching strategies of drill and practice, memorization, recall of facts, and solving word problems based on basic rules and procedures. Jackson asserted that,

> *I used, drill and practice, recall and memorisation of facts. Sometimes, solving enough examples for the students in the class will help them recall the*

right procedure to follow when activities are given for practice. (Jackson: Workshop: 2011)

Another participating teacher, Jerry, said,

There are so many methods used in teaching mathematics depending on the teacher and the topic to be taught; for me, I used different teaching techniques like demonstration, lecture and instructional aides to aid and guide my classroom teaching and learning. (Jerry: Workshop: 2011)

In other words, most of their classroom approaches can be called teacher-centred where the teacher is in control of the classroom processes and is the main source of knowledge. Students are often expected to acquire their knowledge through listening and mimicking teachers' actions. These practices are in contrast to constructivist principles of teaching that highlight students active role in constructing their knowledge using their background experience either from outside school or from the previous class and using their discussions and negotiation of meanings among themselves and with the teacher. Perhaps the above observations are not surprising. They probably reflect the status of mathematics teaching in Nigeria as the review of literature above indicated.

The teaching methods which the participating teachers identified in the workshop showed a gap between the current practices of the teachers and those promoted by the Productive Pedagogies framework. These traditional teaching methods fail to match some of the characteristics of good teaching as promoted by Productive Pedagogies. In particular, employing Connectedness where students could use their initial knowledge to construct new knowledge is not generally achieved through drill and practice. Similarly, there is a doubt that these traditional techniques would achieve Intellectual Quality that requires students' higher order thinking and substantive conversation through the sharing of ideas and opinions among the students.

In justifying their views for resorting to the traditional teaching approach, the participating teachers argued that selecting teaching strategies in the classroom is often determined by several conditions. Such conditions include the number of students a mathematics teacher had in the class, the readiness of the students to learn and the availability of time the teacher had to cover the content. For example, Jackson said,

> *Students' readiness to learn, and the time a teacher has at his disposal determine his approach or method use. Because if the class is too large or you don't have time, the best thing the teacher can do is to simply teach and work away. That is using the traditional lecture method and gives them classwork. (Jackson: Workshop: 2011)*

Perhaps, on the surface, comments such as these indicate that the participating teachers are in agreement with the Supportive Classroom Environment and Recognition of Difference dimensions of Productive Pedagogies where teaching is designed to cater for students' needs and readiness. However, this more likely demonstrated a lack of reflection on students' experiences and learning by the participating teachers and it also demonstrated their lack of knowledge of more effective ways of teaching, and of managing large classes and students at different levels of mathematical knowledge.

In discussing their teaching practices, the participating teachers also highlighted traditional assumptions about student learning. For example, both Jerry (teacher) and Julie (student) believed that effective teaching and learning of mathematics should be structured to build mathematics from simple to more complex knowledge and from simple problems to more complex ones. Jerry opined,

> *In my own opinion…, as far as teaching is concerned…, the teacher is supposed to start it, from simple problems to complex…, (Jerry: Reflection Meeting: 2011)*

Similarly Julie was also of the view,

> *I think things had to be taken gradually for students to understand. I think it's the best to work gradually so that students can really follow what you are doing. And one had to start from simple to complex, so that you don't lose your students' interest. (Julie: Focus Group: 2011)*

Once again, this understanding of student learning can be interpreted as an application of the element of Connectedness in the Productive Pedagogies framework where new knowledge is built upon previous knowledge. Mathematics in particular is often seen as hierarchical and that the lower order concepts and skills have to be mastered before the higher order ones. However, this raises a question about how this principle relates to the problem based learning also promoted by the framework. Arguably, using the problem based approach indicates that students may be presented with problems for which the concepts and skills may not have been developed in advance. The problem situations would be the platform to raise the new understandings and skills - of course by using students' background knowledge.

4.2.2: Classroom Problems and Productive Pedagogies

The second activity that was initiated for the introduction of the Productive Pedagogies framework was designed to relate the various elements and dimensions of the framework to the problems and difficulties that the participating teachers might have encountered in teaching mathematics in previous years. The rationale behind this activity was to help the participating teachers to think about how to link the classroom challenges with the possibility of using some dimensions or elements of the Productive Pedagogies framework in managing them.

Several problems were identified by the participating teachers. At the early stages of the discussion, problems were identified based on the learning of mathematics by students. In some ways, they indicated that these are problems in the students themselves, rather than problems in teaching. For example, one teacher said:

> *The problem I mostly faced in my class is students' understanding of mathematics questions given and the procedure to use to approach the problem. (Jennie: workshop: 2011)*

Perhaps this is not uncommon language for teachers of mathematics, in Nigeria at least to use to discuss lack of student achievement, in terms of their lack of ability, interest and effort. Jennie also looked at the classroom problems in relation to the abstract nature of mathematics as viewed by students. She was of the view that,

> *Some students view mathematics as being too abstract. We can also say the abstract nature of mathematics makes students dislike mathematics and hence have problems with it. (Jennie: workshop: 2011)*

It is perhaps undeniable that for many students mathematics is seen as a highly abstract subject. However, stating the problem as a student problem hides the challenge that teaching can, and should, attempt to develop mathematical knowledge in ways that makes it meaningful and useful for students. Arguably the Connectedness dimension of Productive Pedagogies provides criteria by which teachers can plan for their teaching to make the mathematics classroom teaching real and practical.

However, not all problems raised in this session were constructed in terms of student problems. One teacher, Jackson, put it this way:

> *Of a truth there are cases where teachers should be blamed for the problems affecting our mathematics teaching. Let us face reality and see how teaching could be better. (Jackson: Workshop: 2011)*

As the discussion progressed, more comments from the teachers were centred on the challenges that student difficulties implied for them and their choosing of appropriate pedagogies to deal with classroom challenges. For example, Jerry asserted

> *The problems mathematics teachers have in their classroom include their self-centredness. That is when most mathematics activities given in the class are teacher-centred and not student-centred. It makes teaching and learning in the class difficult for the students. (Jerry: Workshop: 2011)*

Another teacher expressed the view that teachers do most of the talking and disregard students' contributions in the classroom. The participating teacher went further to say that sometimes teachers disallow students the opportunity to asked questions to clarify their ideas. For example Jimmy said,

> *Mathematics teachers don't allow students to participate in the problem solving in the class. They do all the talking and students' contribution is not regarded; they sometimes don't allow students to ask questions in the class. (Jimmy: Workshop: 2011)*

For these teachers at least, there was an acknowledgement of a need for change from the traditional teacher-controlled mathematics classroom to more student-centred approaches. There was an acknowledgement that major challenges facing mathematics teaching and learning today in most Nigerian mathematics classrooms is the mathematics teachers' self-centred approach to teaching as stated by Jerry above. Further, there was a shared view that a shift from this dominant attitude to allow a more accommodating classroom where students will have the opportunity to construct their knowledge and contribute to the learning in the class would allow teachers to meet the challenges identified. No wonder one of the students, Janet lamented later by saying,

> *Students really need a free and fair classroom environment where everybody will have the opportunity to approach the teacher on areas of misunderstanding…, (Janet: Focus Group: 2011)*

After this discussion, the researcher asked the participating teachers how the challenges identified correspond to the dimensions and elements of Productive Pedagogies. In other words, the researcher encouraged the participating teachers to identify specific elements of the framework that may allow them to change their pedagogy to manage the challenges they raised. At first, the participating teachers had difficulties relating the classroom problems or challenges to the various dimensions of Productive Pedagogies. Perhaps, the task was not familiar to them. They needed some scaffolding. As a result, they were able to examine the material given to them prior to the workshop.

For example, one problem identified as a challenge for mathematics teachers was that of students' difficulties in understanding mathematics problems and the appropriate strategy to use to solving such mathematics problems as discussed above by Jennie. The participating teachers were not able to identify a particular dimension of Productive Pedagogies that could be used as a characteristic of good teaching to address this problem. The researcher suggested that understanding mathematics questions required the mathematics teacher to adopt the Intellectual Quality dimension during teaching. Intellectual Quality focuses on developing students' deep-understanding in worthwhile and meaningful contexts that will require them to use higher order thinking which goes beyond simple recall, recognition, and reproduction of facts.

From the scaffolding, the participating teachers were able to see the links between the classroom problems they had earlier mentioned with the various dimensions of Productive Pedagogies. For example, to deal with the problem of the abstract nature of mathematics discussed above, Jackson, using Productive Pedagogy language, identified ways in which the teachers can improve students' views of abstract mathematics concepts. In Jackson's view, if students are taught mathematics without making any connection with real life situations, ideas learned with no link to the contexts in which they arise will make mathematics look too abstract to the students. Therefore, mathematics teachers should make their mathematics real and practical to their students. Jackson suggested,

> *If our mathematics is made real and practical to the students the abstract nature of such mathematics will be overcome because, if the students view mathematics as abstract the mathematics teacher need to relate his mathematics to the world around them to break this abstractness. (Jackson: Workshop: 2011)*

In summarising this discussion, the researcher noted two general patterns. In discussing the challenges teachers encountered in their previous attempts to teach mathematics, there was a noted shift from constructing the problems in terms of students' difficulties to the challenges of pedagogy that can deal with these difficulties. In general, first, the teachers observed and accepted that the overall teacher-centred classroom environment was seen as not supporting effective student learning. Second, the teachers have started to make connections with the elements and dimensions of the Productive Pedagogies for indicating certain directions in pedagogy to meet these challenges.

4.3: Effectiveness of Major Means of Scaffolding

The researcher has taken a significant responsibility in choosing the Productive Pedagogy framework in the first place and has taken an active role in introducing the framework to the participating teachers. However, the researcher was not the sole source of scaffolding. The project was designed to involve the teachers themselves in a "community of practice" where the teachers provided assistance to one another in expanding their understanding and use of the framework. Naturally, the researcher took a larger role in the first part of the project. However, as the project progressed, the participating teachers played an increasing role in supporting each other towards reflection on their practice and commenting on each other's attempts to improve their teaching by incorporation of the framework into their practice.

This section considers the means employed to identify areas where the participating teachers needed scaffolding. The first of these means was the classroom observations by the researcher and the other participating teachers. The second was the reflection meetings held between the participating teachers and the researcher to identify challenges they had encountered and to seek or give assistance to each other. The third was the comments raised by the focus group students during focus group discussions.

4.3.1: Classroom Observations

One of the means employed to identify areas where the participating teachers needed scaffolding was through classroom observations. This assisted the researcher to determine what kinds of scaffolds are appropriate and how much scaffolding is appropriate for each of the participating teachers during the research process. For example, the researcher monitored the participating teachers' responses to their students during their classroom teaching to find ways to ensure that the teachers make personal meaning of their experiences and develop a fuller understanding of the implementation of the framework. The researcher employed similar monitoring strategies during reflection meetings to identify the difficulties the participating teachers had and to provide scaffolding that assisted them in using the Productive Pedagogies framework to achieved quality teaching.

Another area where observations were used as a means of identifying areas where scaffolding was needed was what the researcher called peer observation. This is because observations were not restricted to the researcher monitoring the use or non-use of the Productive Pedagogies during the classroom teaching and reflection meetings with the participating teachers. The participating teachers were trained to observe their colleagues during classroom practice. Generally, such classroom observations were used as a means to collect information about the progress and weaknesses of the participating teachers. Information collected from such observations was used by teachers during reflection meetings to reflect on their practice and possible suggestions were made to improve one-another's practice.

The peer observations were viewed by the participating teachers to be useful tools for improving their practice. According to the participating teachers, observations that suggested that the teachers required further assistance were reported either in the class while observing their colleagues or during reflection meetings. Jerry suggested that peer observations help teachers improve since they will not be able to observe their areas of difficulties while teaching. As such, they need professional colleagues to observe their weaknesses and strengths. These observations helped them to monitor the progress that they were making and to identify their areas of weakness. Jerry said,

> *when a teacher is teaching he may not consider a particular situation necessary…, he may be thinking that he may have handled it…, that is why we have the observers…, so they are in a better position to know whether a particular element is demonstrated or not…; I cannot be presenting my*

lesson and be observing myself at the same time …, (Jerry: Reflection Meeting: 2011)

Similarly, the participating teachers were of the view that peer observation helped boast teachers' confidence and interest in teaching, as there is a feeling that someone somewhere is watching, and what the teacher is doing will be criticised and corrected and so the mathematics teacher will be encouraged to do better. One of the teachers reflected on the benefits and said,

This helps me approach my research with a sense of belonging that there are people that will support, encourage and criticise you at each stage of your work. (Jennie: Research Journal: 2011)

This suggests that peer observation during the research gave the participating teachers the opportunity to give and receive help, not necessarily from the researcher but from a colleague. Another participating teacher supported this by saying,

The way the program was structured emphasises very challenging learning objectives, we received and provided support to one another, and not only is feedback given throughout the program but we actively sought for it, not only from the researcher, but also from colleagues. (Jackson: Research Journal: 2013)

Similarly, peer observation helped mathematics teachers in developing new strategies for problem solving and this could be transmitted to developing students' problem solving skills. The participating teachers suggested that R2. CH4teachers. This participating teacher, Jackson, said,

The experiences of discussing with colleagues helped my problem solving skills, it provided opportunity for cooperative learning, and there is an enhanced level of immediate feedback. (Jackson: Research Journal: 2013)

4.3.2: Reflection Meetings

The need to implement a scaffold occurred when the researcher realized that the participating teachers were not progressing on some aspect of a task or were unable to understand particular concepts. In this section the researcher discusses how the scaffolding was provided to the participating teachers during the reflection meetings. Generally the scaffolding provided at this time adopted dialogue, discussions, debates and explanations for the participating teachers. These discussions were characterised by comparatively lengthy interactions between the researcher and the participating teachers and between the teachers in a context of collaboration and mutual support.

In most cases these discussions came from the observations made by the participating teachers on the classroom teaching of their colleagues, or issues raised by the focus group students during their meetings or from the researcher's personal observations on either the classroom practice of the participating teachers or the interactions during reflection meetings. Similarly, these discussions could also come from the questions raised by the participating teachers on areas where they needed further clarification to improve or to achieve quality classroom teaching.

The benefits of these dialogues and discussions were identified and demonstrated from the research. For example, Jackson was of the view that these were designed to help the participating teachers build understanding, explore ideas, practise thinking through and expressing concepts that will help them achieve quality classroom teaching. Notes from the Research Journal suggested that,

> *Discussions and dialogue allows us teachers to have thoughts we could not have had on our own, yet to recognise these thoughts as developments of our own thinking. (Jackson: Casual Interview: 2013)*

Jackson was also of the view that these discussions and dialogues assisted teachers in developing new strategies for reasoning, enquiry and negotiation of ideas and to provide opportunities for cooperation among participating teachers. Jackson reflected that,

> *Personally, the experiences of discussing with colleagues helped my problem solving skills, it provided opportunity for cooperation, and there is an enhanced level of immediate feedback. (Jackson: Casual Interview: 2013)*

Still on the benefit of dialogues, Jennie was of the same view as Jackson and suggested that this form of scaffolding helps build a framework to guide the participating teachers in developing and constructing their own ideas, skills, concepts and/or processes to improve their practices. For example Jennie reflected,

> *when problems are generated we all discussed together to find a common approach that could be used to address such problems, this help me approach my research with a sense of belonging that there are people that will support, encourage and criticise you at each stage of your work. (Jennie: Casual Interview: 2011)*

Finally, in Jackson's view, dialogues and discussions provided avenues for the participating teachers to receive immediate feedback from professional colleagues. They also helped to strengthen and broaden the understanding of the participating teachers and provided feedback on their strengths and weaknesses during classroom teaching. For example he said,

> *The way the program was structured emphasises very challenging learning objectives, we received and provided support to one another, and not only is feedback given throughout the program but we actively sought for it, not only from the researcher, but also from colleagues. (Jackson: Casual Interview: 2013)*

4.3.3: Focus Group Students

In the focus groups, students provided valuable information that helped the researcher to identify areas where the participating teachers needed scaffolding. For example, in cycle 1, the students raised some important issues during the focus group discussion on the classroom teaching of the participating teachers. These views were discussed during reflection meetings which constituted part of the scaffolding. Even though the participating teachers were not part of the focus group discussions, the information that the researcher collected was discussed during reflection meetings and some of the suggestions the students raised constituted important lessons that served as scaffolding to the participating teachers.

One may be tempted to say the students were too young to determine the effectiveness of Productive Pedagogies in their classroom learning. However, from the interaction of the researcher with the students during focus group discussions, their comments and suggestions demonstrated that they knew what good quality classroom teaching is. They also made profitable suggestions and criticisms that constituted important lessons the participating teachers needed to learn to improve their classroom teaching. For example in cycle 1, Julie suggested that,

> *Since students dislike and fear mathematics today, mathematics teachers are not supposed to be strict and scare students away from their classroom teaching. (Julie: Focus Group 1: 2011)*

She went further to suggest that,

> *Mathematics teachers are not supposed to be strict and scare students away from participating in mathematics classroom practice. It is not a quality of a good mathematics teacher. To my own understanding mathematics teachers are supposed to be friendly to students. Students are finding it hard today to learn mathematics because of the strictness of some mathematics teachers. (Julie: Focus Group 1: 2011)*

Julie's suggestion above demonstrated that effective mathematics classroom teaching can only be achieved if there are good teacher-student relationships. From this view, Julie was trying to demonstrate the importance and the application of the Supportive Classroom Environment dimension of the Productive Pedagogies framework. Janet concurred with Julie when she commented on Jackson's mathematics classroom teaching and suggested that students need a free and fair classroom climate that will give them the opportunity to approach their teacher in difficult situations. She claimed,

> *Students really need a free and fair classroom environment where everybody will have the opportunity to approach the teacher on areas of misunderstanding…, and Jackson created this atmosphere in cycle 2. So in short he improved. (Janet: Focus Group 2: 2011)*

Another lesson learned from these discussions is that the students did not only make suggestions on how teachers could make their classrooms teaching better. They also make some constructive criticisms that constituted the subject for scaffolding during planning and reflection meetings. For example, Julie suggested that some of the participating teachers demonstrated a lack of confidence and courage in their classroom teaching, and that such lack of confidence and courage affected their effectiveness. She said,

> *The teachers did not demonstrate courage and confidence in their work. In fact sir, this makes one of the teachers too fast, he made the class too boring and uninteresting, if you are lost out to come back and clique to what he is doing is difficult. (Julie: Focus Group 1: 2011)*

Julie suggested that it is good for mathematics teachers to take teaching gradually, not to rush their students, if such teachers desire students' understanding of their classroom teaching. And that effective teaching should be done starting from simple to complex. She said,

> *I think, just that he has to take things gradually for students to understand. I think it's the best to work gradually so that students can really follow what you are doing. And one had to start from the simple to the complex, so that you don't lose your students interest. (Julie: Focus Group 1: 2011)*

4.4: Areas of Scaffolding Provided

This section looks at the specific areas of scaffolding provided to the participating teachers during the research. Specifically this is discussed in two sections. First, the researcher discusses the need for developing confidence in implementing the Productive Pedagogies framework. Second, the researcher discusses challenging the traditional teacher-centred approach adopted by the participating teachers in the cycle 1 and how scaffolding was used to assist the participating teachers to improve their teaching.

4.4.1: Developing Confidence

Nervousness was viewed in situations where teachers demonstrated some initial feelings of tension while attempting to use the Productive Pedagogies framework as a tool to achieved quality classroom teaching. For example, in cycle 1, Jackson observed some elements of teacher nervousness in some of the classes he observed. According to him, this nervousness was demonstrated in the form of poor classroom control and in the use of incomplete sentences during classroom teaching. He said,

> *The teachers I observed showed some nervousness, which is they were not confident in their presentation of facts to the students. This led to some problems in their teaching. For example I observed that there was weak classroom controls, as they did not really have the grip of the class. I also observed in one of the classes that there were constant used of phrasal expression, I mean the teacher sometimes starts a sentence without really completing it…,which I think affected the teacher. (Jackson: Reflection Meeting 1: 2011)*

In supporting what Jackson said, Jennie also observed these elements of nervousness in the classes she observed. For example, she was in Jimmy’s classroom and discovered that he demonstrated nervousness during his teaching. She was of the view that this nervousness was demonstrated through the teacher-centred teaching and the use of incomplete steps in solving mathematics problems which she feels affected the teacher's classroom instruction. Jennie reflected;

> *His teaching was mostly teacher-centred…, he was doing most of the talking without involving the students…, he made incomplete sentences which involved frequent missing of relevant words, his steps were inconclusive…, I think…, all these could be termed evidence of nervousness in his teaching. (Jennie: Reflection Meeting 1: 2011)*

Similarly, when the researcher met with the focus group students, their general view was that most of the teachers demonstrated nervousness in cycle 1. For example, Micah was of the view that Jimmy and Jennie demonstrated nervousness in their teaching. According to him, the two teachers were afraid of the class, which made them make some mistakes especially in their use of tense. In support of the above he said,

> *Two of the teachers were like nervous in their speech…, this makes them makes a lot of grammatical errors when they were talking…, I think they need to perfect their tenses…, for example; Jennie was like a little bit nervous at the beginning. She was jittering in her talking which made her make some mistakes in her use of English. She was like afraid of the class. (Micah: Focus Group 1: 2011)*

Another student was of the view that some of the participating teachers demonstrated nervousness by showing a lack of confidence in presenting their lessons. For example, Julie commented that this lack of confidence made Jimmy look too serious and unfriendly to the students; as a result his teaching was boring and uninteresting. She supported this by saying,

> *It was like Jimmy did not demonstrate courage and confidence; he was like looking too serious for my liking and was also unfriendly with the students. In fact sir, this makes the teachers talk too fast, he made the class too boring and uninteresting, if you are lost out to come back and clique to what he is doing is difficult. (Julie Focus Group 1: 2011)*

Janet made the same comment when describing one of the participating teacher's teaching. She was of the view that,

> *To me, it was as if the teacher was having this problem of courage…, this is because the foundation he laid for us was too shallow…, as if he has no basic foundation of what he wanted to teach us.., he was too fast and had no students in mind while teaching …, In short he was nervous. (Janet: Focus Group 1: 2011)*

Perhaps this nervousness might be the result of the general belief that teachers, students and indeed all human beings generally exhibit some levels of anxiety when doing certain things for the first time. For example, Jerry viewed initial nervousness as normal for student-teachers and even some experienced teachers. He was of the view that since they were meeting Productive Pedagogies for the first time, initial nervousness is likely to be exhibited. He went further to suggest that as the research progresses such initial nervousness will gradually reduce.

> *There is bound to be some nervousness and even lapses in the implementation of Productive Pedagogies at the initial stage, because this is the first time we know this, hence in its implementation there is bound to be some initial nervousness, lapses, and mistakes. I think as we grow from cycle to cycle we shall develop some more stamina to do well. (Jerry: Reflection Meeting 1: 2011)*

Similarly, experience has it that initial nervousness is generally exhibited by student-teachers when they are being observed, especially during teaching practice. Therefore, these participating teachers might have exhibited this nervousness as a result of feelings of being student-teachers under some observational conditions. Finally, this nervousness could perhaps be a consequence of mathematics teachers' negative beliefs about their mathematics ability which could be attributed to their poor prior teaching experiences, poor self-confidence, and poor communication of their mathematical knowledge and abilities. This position was supported by the comments of the students' that indicated that the teachers were not confident in presenting what they had prepared for the students.

> *The teachers did not demonstrate courage and confidence in their work..., For example; if you are lost, to come back and join up with what the teacher is doing is difficult. (Julie: Focus Group 1: 2011)*

In view of these observations and possible reasons behind the exhibition of nervousness by the participating teachers, the researcher and the participating teachers suggested strategies that could be used to help increase the confidence of the participating teachers. For example, the first suggestion was provided by the researcher who suggested that they should avoid making their mathematics classroom teaching look too abstract to the students. If they are able to create activities that are real and practical to their students and get the students involved in such activities, teachers' nervousness could possibly be reduced. This is in line with Connectedness to the world and the students' direction. The researcher's Research Journal notes reported that:

> *If teachers make their mathematical concepts too abstract to their students it will make the lesson uninteresting and as such increase teacher nervousness. (Research Journal: 2011)*

The researcher supported this assertion with the comments made by students during focus group discussions. For example, the students were of the view that involving them in real life practical problem solving during classroom teaching could help in improving the confidence of their teachers.

Jackson also suggested that becoming familiar with developing creative strategies to design lesson plans for teaching mathematical concepts would also help reduce nervousness among teachers. He was of the view that in planning their lessons teachers should think through and come up with creative activities that will motivate students to use their higher order thinking skills, and that this will help boost teachers' confidence during their classroom teaching. Jackson was of the view that,

> *Though we started slowly and were working alone, but as we continued we will develop some confidence to get the students involved in what we were doing…, we really need to sit and think on the strategies to use in motivating ourselves and our students before coming to class…, we have to study harder also so as to know how these elements could be implemented. (Jackson: Reflection Meeting 1: 2011)*

After this issue was discussed in a reflective meeting the participating teachers took time to prepare more for the subsequent cycles. And from the researcher's observations and that of the participating teachers there was a general agreement that some of the suggestions given above helped the participating teachers develop some confidence in their work in cycles 2 and 3. For example, in cycle 2 Jackson observed that despite some traces of nervousness still being evident in some of the participating teachers' instruction, they progressively developed courage and confidence in their classroom teaching.

> *Though the teachers started slowly and were working alone ..., as they continued they developed some confidence and got the students involved in what they were doing. (Jackson: Refection meeting 2: 2011)*

The focus group students also observed some improvement in the participating teachers' practice. For example, Mike and Micah were of the view that though the participating teacher took their classroom teaching gradually in cycle 2, as they progressed, their confidence improved. Mike suggested that Jimmy started his teaching in cycle 2 gradually, progressively and got his students involved in what he was doing. This was an improvement from what happened in cycle 1 where nervousness made him look too rushed and unfriendly to the students. Mike comments were that:

> *In cycle 2, he improved very well in his presentation and hence was not too nervous as in cycle 1. Because during his teaching he took it gradually and follow it gradually in bringing out the solution to the problem…, this time, he gave room for students' contribution hence there was student participation and interaction among students. (Mike: Focus Group 2: 2011)*

Micah observed a general improvement in confidence in all the teachers in cycle 3 and said that the teachers demonstrated good teacher-student relationships which made the lesson more interested. This demonstrated that when mathematics teachers show confidence in their work, it brings about improvement in teacher-student relationships and hence improved student interest in what the teachers are teaching. In supporting this assertion, Micah said,

> *Truly, this time around the teachers were not as nervous as they were in cycle 1. The mathematics teachers make their teaching very interesting; students were interested and pay close attention to what they were doing in the class. The teachers brought the students together and it was like there was good interaction between teachers and students and between students. (Micah: Focus Group 3: 2011)*

4.4.2: Challenging Traditional Teacher-Centred Approaches

During the workshop, the researcher and the participating teachers discussed extensively on the importance of student direction and self-regulation, some of the participating teachers were of the view that students' direction should not have been included as an element of Supportive Classroom Environment. They argued that relinquishing classroom control to students is not a wise idea as this could make some students take over the class and make the classroom ungovernable and be disruptive to classroom teaching. One of the arguments presented was from Jackson who supported the view that mathematics teachers are to explicitly determine what activities students should do and how such activities should be done if teachers hope to meet their classroom objectives. He said,

> *When the teacher is in the class, he is supposed to be in control of all the activities in his class. He should be in-charge of directing all the affairs of his class: - allowing students to take control of the classroom activities might be counterproductive. (Jackson: Workshop: 2011)*

Such views about strict control of classroom are widely held among Nigerian teachers. For example, on classroom discipline, James argued during the workshop that there are students who will never learn anything in the class if the teacher did not subject such students to some sort of punishment, and in his view self-regulation might not be possible for students at this age. The teacher argued that, if we hope to have a classroom where every student's needs in the class is identified and met; discipline should be enforced even if the teacher is going to "use the cane". The teacher was of the view that there are students in our classes who will never learn if they are not "pushed to the wall". The teacher argued,

> *Yes, that one is being done. But there are students for whom, if there is no pain there will be no gain and the idea of Productive Pedagogies is to carry everybody along whether slow learners or the gifted ones. So in order to carry them along and make sure they participated in the classroom activities, we have to cause them some pains to get the best out of them. You know there are some students that are best identified through these. (Jackson: Workshop: 2011)*

Jennie had a contrary view, saying that teaching students or guiding students to be self-disciplined is better that enforcing discipline in the class. She was of the view that, since we have learnt about self–regulation, teachers are better adopting it than carrying a cane. Jennie said,

> *Sir truly based on our African cultural context; I will say there is nothing wrong with the use of cane, but what we are saying here is that it should not control the class. However as mathematics teachers, I feel we should inculcate in students self-discipline. We talked about self-regulation, why not teach the students to be self-disciplined instead of using the cane? It all depends on the way teachers approach it. I think I have learnt that this self-regulation is good for our students instead of carrying a cane about. (Jennie: Workshop: 2011)*

The remarks of Jackson above suggest that the participating teachers did not adopt the Productive Pedagogies framework without critically considering their cultural and environmental factors. They viewed it critically using the Nigerian mathematics classroom context. They then suggested that allowing student direction and self-regulation in the Nigerian classroom context could be counterproductive to effective classroom teaching. Perhaps, their reasoning could be explained, because they are so entrenched in their old habits of teacher-centred traditional classroom teaching that they failed to imagine alternatives that could be adopted to achieve quality classroom teaching. This also suggested that the participating teachers lacked awareness about the benefits of these two elements of Supportive Classroom Environment.

The researcher gave further explanations on the importance and implications of not including students' direction and self-regulation in the Productive Pedagogies framework. However, despite these explanations there were still disagreements between the teachers on the benefits of these two elements in effective classroom teaching. In their disagreement, perhaps, they failed to accept the fact that in developing positive and mutually supportive mathematics classroom relationships, breaking down power imbalances between them and their students is necessary.

Similarly, they failed to accept the fact that the literature showed that many students resist being overpowered and controlled by their mathematics teachers. Such students sometimes demonstrate this by creating unnecessary apprehension during classroom teaching. Finally, they forget the fact that when teachers create a responsive classroom environment for their students, it tends to make their students less apprehensive about their creative expressions (Meyers & Turner, 2002).

In view of this situation, the participating teachers faced challenges in cycle 1. For example, the students resisted their teacher-centred or traditional approach to teaching in which the participating teachers dominated the activities in the class. Micah was talking on the teaching of Jimmy and said,

> *The teacher was just working alone, he was just writing on the board. Even when he gives students problems to solve, he will not allow us to finish it, he will just go to the board and solve the problem, and students were not part of the lesson as we learnt during the workshop. (Micah: Focus Group 1: 2011)*

The students also observed that in cycle 1 most of the participating teachers failed to accept these responsibilities of creating a classroom learning environment that will give room for students' direction and self-regulation. For example, in Jimmy's class the students were of the view that he was too serious and lacked good classroom control. Hence the students found it difficult to participate in his classroom teaching. Jane complained,

> *He had no good classroom management; this affected the students' classroom participation. He was just talking to the board that is the interaction was just between the teachers. The chalkboard called, the teacher did not have students in mind, Mike was right. (Jane: Focus Group 1: 2011)*

This situation resulted in an unfriendly classroom climate between the teachers and their students in cycle 1. For example, Janet was of the view that Jackson was too strict and unfriendly to the students during his classroom teaching. She complained that,

> *The mathematics teacher was too strict, too over-serious, and he was not friendly, I mean he did not allow the students a breathing space; he shouts the student down when he discovers that the student makes a little mistake. (Janet: Focus Group 1: 2011)*

Other students made similar comments about other teachers. For example, the following comments were made on Jimmy's classroom teaching in cycle 1.

> *He had no good classroom management (Jane) He was too serious and unfriendly for my liking (Julie) He was too fast; he had no students in mind while teaching (Mike). (Focus Group 1: 2011)*

Julie argued that the personality of a teacher means a lot to the students. If the teacher is friendly and accommodating he or she will receive students' cooperation during classroom teaching. Otherwise, she was of the view that no matter how good such a teacher is, students pay less attention to the teacher's classroom teaching. Julie argued,

> *See sir, sometimes the mood in your face alone makes people to be attracted or run away from you. If your mood is friendly the students will be willing to listen to you. But when your mood is not friendly and you "tie your face" (meaning not being friendly or approachable), I personally will be scared of you and whatever you are saying; I will not pay attention to you. I will not enjoy or understand what you are saying as a teacher in the class. (Julie Focus Group 2:2011)*

In supporting what Julie said, Janet was of the view that effective classroom teaching gives room for a free and fair classroom climate where students have the opportunity to interact with their teachers, especially in times of difficulty. She also argued,

> *Students really need a free and fair classroom environment where everybody will have the opportunity to approach the teacher on areas of misunderstanding…, and Jackson created this atmosphere in cycle 2. So in short he improved. (Janet: Focus Group 2: 2011)*

In view of the challenges discussed in the section above, it became obvious that the participating teachers needed further assistance in improving teacher-student relationships. It also implied that the traditional dominated teacher-centred approached they discussed during the workshop did not help them achieve quality classroom teaching in cycle 1.

For example, in the views above, Julie expressed the feelings of students on the relationship that should exist between teachers and their students during classroom teaching. This view suggested that students who have close, positive and supportive relationships with their teachers usually pay closer attention to the teachers than those students with more conflicting relationships. Similarly, from the views of Julie, it is pertinent to observe that a mathematics teacher's personality contributes a lot to determining the factors that promote students' mathematics classroom participation and understanding. This is because positive teacher-student relationships draw students into the process of learning and help promote the desire in students to learn.

Closely related to the views of Julie, Janet was of the view that mathematics teachers who foster positive relationships with their students create classroom environments that are more conducive to learning and that this helps to meet the social, developmental, emotional and academic needs of the students. Therefore, if students feel personal connection with their teachers, experience frequent communication, and receive more guidance and praise than criticism from their teachers, such students are likely to become more trustful. These students also show more engagement in the academic content presented, display better classroom behaviour, and most likely will attain higher levels of academic achievement than students who are not allowed such access to their teachers.

Therefore, during reflection meetings, the researcher and the participating teachers interacted on the comments and suggestions raised by Julie and Janet. Their views according to the participating teachers were accurate especially as they critically reviewed their practice and discovered that they needed a change of approach to their classroom teaching. For example, Jennie was of the view that, in her cycle 1, she did not tolerate students' misbehaviour and hence she did not give them the opportunity to interact. In her efforts to instil discipline in the class students' interaction was denied and this affected her classroom practice.

> *We did not tolerate their misbehaviour; I did not really allow students interaction during my classroom practice. I insisted they should be quiet in the class and listen when I am teaching; I think with these comments in the next class I will try to be friendlier and allow students some level of freedom in my class. (Jennie: Reflection Meeting 1. 2011)*

In his argument Jackson was of the view that sometimes allowing students to take control of their learning in the class might lead to wasting classroom teaching time and hence make it difficult for the teacher to achieve his/her objective of completing the day's lesson.

> *The truth is that for effective teaching in my view is the mathematics teacher must dominate and control the classroom activities. If not sir…, one will find it difficult finishing what he has prepared for the class. (Jackson: Reflection Meeting 1:2011)*

This view suggests that it is possible for mathematics teachers to establish positive and friendly relationship with their students without giving up classroom control and management. This is also in line with the view of Jennie at another time when commenting on her observation of Jimmy's classroom teaching. She asserted that,

> *If a teacher really established a good classroom management, there would not be the problem of poor teacher-student relationships; let us agree that establishing good and effective classroom relationships precedes effective and good classroom control or management. We should also accept that our students need some element of freedom in what they are doing in the class. (Jennie: Reflection Meeting 1: 2011)*

Following Jackson's argument and the suggestion of Jennie, there was a general consensus among the participating teachers that the views of the students were very important and should be respected. They resolved to change their approach to teaching from the teacher-centred traditional approach to a more friendly student-centred approach to teaching. They also resolved to work with the students and give them some opportunity to take control of their classroom activities.

For example, in cycle 2 Jimmy adopted the suggestions raised by the participating teachers and the students in his classroom teaching. Jerry, who observed the improvement, asserted that Jimmy involved the students in the classroom activities and from his observation there were student-student interactions in their quest to find solution to the challenging question given to them. This demonstrated substantive conversation between students during the lesson compared to what he called the self-centred approach to classroom teaching. This was what Jerry said:

> *He allowed the students to battle with the question and come up with their solution, there was a lot of substantive conversation between the students and they were seen working together asking questions from one another in order to get the direction to the problem raised in the class. So I can say based on what happened above there was higher order thinking and there was substantive conversation between students as against self-centred approach seen in cycle 1 where it was only the teacher talking with little teacher-student conversation. (Jerry: Reflection Meeting 2: 2011)*

Jennie observed that there was improvement in Jimmy's classroom teaching. She asserted that in cycle 1, Jimmy demonstrated the teacher-centred traditional approach to teaching which did not yield positive results. Jimmy, however, changed this approach in cycle 2 by allowing student engagement through classroom participation. And that yielded positive student interactions during classroom teaching. She said:

> *We can really see how the classroom participation was going on. Student to student interaction was going on and student to teacher that they were also asking the teacher questions on how to really go about the solution to the problem. This shows improvement from the teacher-centred approach seen in cycle 1. (Jennie: Reflection Meeting 2: 2011)*

Jackson was of the view that due to the high Intellectual Quality problem given to the students in the class, Jimmy allowed his students to take initiatives in the class. From his observation, the students were observed using their background knowledge and knowledge integration to identify the possible ways to find a solution to the problems. Jackson said:

> *Yes sir, he got the students working on their own, and in groups, he was only moving around to see what the students were doing and offer helps where necessary. The problem was so challenging that the students had to use their background knowledge and knowledge integration. For example, from the question given to the student which was beyond their abilities, I observed in one of the groups they had to use their knowledge of surd in order to really bring out the solution of the quadratic equation they were solving. Without this the students would have found it difficult to crack the difficult and the highly Intellectual Quality question given to them. This demonstrated that Jimmy improved in cycle 2. (Jackson: Reflection Meeting 2: 2011)*

This suggests that when teachers get their students involved in classroom activities and give them the freedom for initiation and construction of knowledge, students tend to use their initiative to identify possible strategies to solve their problems and in turn this encourages independence and collaboration among students as asserted by Jennie and Jerry above.

Another example that demonstrated improvement from the traditional teacher-centred approach to teaching to a more student-centred approach was observed in Jackson's classroom teaching. Jennie commented that there was improvement in Jackson's relationship with the students during his teaching because he got the students involved in his teaching. Jennie observed that,

> *This time around sir, Jackson made use of the students. For example, he used the students to cite examples of daily happenings or activities like going to the markets to buy things. He also used two students working together to show how two simultaneous equations, are parallel in short the students were fully involved in his teaching compared to the strict teacher-centred approach he adopted in cycle 1. The students were also relaxed to discuss their problems with him in cycle 2. (Jennie: Reflection Meeting 2: 2011)*

Jerry supported Jennie's observation by saying that,

> *I observed the full participation of the students in his class…, I also discovered that, in the lesson the students were working together…, that is good and showed improvement in his teaching approached. (Jerry: Reflection Meeting 2: 2011)*

Another observation Jennie made was that Jackson was more lenient and democratic in cycles 2 and 3 than what was observed in cycle 1. She said:

> *He really tried..., this time around, he was more lenient…, honestly sir…, (looked at Jackson and then laughed)…, He was more democratic this time in his classroom practice…, Kai…? Before…, sometimes…, towards the end…, if he brings that face…, it really, really, gets students scared. (Jennie: Focus Group 3: 2011)*

Finally, in Phase 1 of the research, Jackson also wondered how the changes were possible in his teaching during Phase 1 of the research. He compared his classroom teaching in the traditional setting with the new setting when he decided to relax his classroom environment and became friendly to the students. This suggests that when mathematics teachers relax their classroom environment and become friendly it increases students' participation even among students with learning difficulties. Jackson said,

> *My classroom used to be like a graveyard…, students dare not talk when I am teaching…, but to my amazement as I introduced the Productive Pedagogies framework in my class, the class naturally became interactive, the students interact in their groups, before you know, the solution to the problem is gotten and even those who fear mathematics you see them ready to defend their answers. (Jackson: Reflection Meetings: 2: 2011)*

Similarly, the students also observed the change of teaching approach in Jackson's classroom teaching. For example, Julie was of the view that Jackson gave room for students' views compared to what happened in cycle 1 where he was very strict and scared students away by his classroom teaching. Julie asserted that the teacher allowed students to make useful and profitable suggestions to the classroom teaching. She said,

> *The teacher asked for students' opinions in solving the problems in the class, which gives us some freedom compared to cycle 1. He asked questions based on groups and gives room for everybody to participate in the class. The teacher makes sure at every stage he links what he is teaching with what the students had known before. (Julie: Focus Group 3: 2011)*

Similarly, Janet was of the view that the teachers became generally friendly and went further to state the need for such a relaxed and supportive classroom atmosphere. Her views suggested that when mathematics teachers relax their classroom environment and become friendly with their students, students also tend to feel relaxed, happy and willing to come closer to the mathematics teacher to seek further assistance. Janet said,

> *I think this time around the teacher was cheerful and friendly; it was like he overheard all our discussion…, students really need a free and fair classroom where everybody will have the opportunity to approach the teacher on areas of misunderstanding…, and the teacher created this atmosphere in cycle 2. So in short the teacher improves. (Janet: Focus Group 2: 2011)*

Janet further commented on Jackson's improvement in cycle 3 by saying that even though Jackson was disciplined (self-regulated), when the students understood him, and he understands the students, there was increased student participation in his mathematics classroom teaching. She said,

> *Jackson is disciplined…, students understood him…, and he also understands the students. This brought about student participation. He has improved in his relationships with the students…, he was cheerful …, and I like him…, (smile). (Janet: Focus Group 3: 2011)*

This view demonstrated that effective self-regulation from the teacher and the students increase students' engagement in mathematics classroom activities. Jane supported the views of Janet and observed improvement in Jackson's classroom relationships with the students in cycle 3. In her view, when students are recognized and respected during mathematics lessons, mathematics teachers attract respect from their students. She was of the view that,

> *The teacher really improved in his mood and facial appearance…, this time he tries his best to respect the class and the class also respected him. He respected the ideas brought by the students; he was not like discarding the comments made by us. (Jane: Focus Group 3: 2011)*

4.5: Summary

This chapter discussed the scaffolding provided to the participating teachers to help them implement Productive Pedagogies during their classroom instruction. This was discussed under four themes. The researcher was able to demonstrate that scaffolding is a tool that the researcher used to assist participating teachers' use of the Productive Pedagogies framework to achieve quality classroom teaching. This according to the analysis was achieved through four approaches.

First, there was the provision of conceptual, material and linguistic tools to support participating teachers' understanding and implementation of the Productive Pedagogies framework to improve their teaching. Second, the researcher was available for discussions, dialogue and interaction with the participating teachers not only during the reflection meetings but in one-to-one discussions. Third, the analysis reveals that the researcher created opportunities for the participating teachers to discuss and dialogue with colleagues on their understanding of the language of Productive Pedagogies. And fourth, peer observation tools were provided for the teachers to rate and observe the implementation of Productive Pedagogies by their colleagues in order to make positive comments and criticisms that helped serve as scaffolding to their colleagues.

It was observed from the analysis that at first, the participating teachers did not approach the concept of Productive Pedagogies with total or complete ignorance. As practicing teachers on in-service training, they had a basic understanding of some aspects of Productive Pedagogies especially the need for creating a Supportive Classroom Environment. Secondly, the analysis revealed that the participating teachers needed scaffolding because of their use of traditional mathematics classroom teaching methods where the teacher dominates classroom activities and restricts students' engagement and involvement during classroom instructions. Thirdly, the analysis reveals that the participating teachers had initial challenges relating classroom problems with the different elements and or dimensions of Productive Pedagogies. However, as the researcher used scaffolding to assist the teachers they were able to use their experiences and began to make connections between their background experiences with the various elements of Productive Pedagogies that could be used to resolve classroom problems.

The analysis also demonstrated some specific scaffolding provided to the participating teachers to help them improve their classroom instructions. There were two major areas of scaffolding that were given to the participating teachers in this chapter. These were the need for developing confidence by the participating teachers in their teaching and the challenges to adopting a student-centred approach to classroom instruction. The analysis showed that initially the participating teachers continued to adopt the traditional mathematics classroom teaching they were familiar with. However, the focus group students who were part of the workshop criticised the participating teachers' traditional approach to classroom teaching.

The participating teachers also made similar criticisms of their colleagues' classroom practice during the planning and reflection meetings. Possible suggestions were made by the researcher, the participating teachers and the focus group students on how these problems could be overcome. Prominent among the suggestions given was that participating teachers should make an effort to apply Connectedness in all their classroom instruction i.e. by making their mathematics classroom problems real and practical to their students. It was also suggested that the student-centred approach is a better alternative in helping to reduce the participating teachers' anxiety and the domineering approach to classroom instructions.

Finally, there were some benefits observed from the analysis as a result of scaffolding provided to the participating teachers. First, the scaffolding provided an opportunity for the participating teachers to link their old knowledge to the new knowledge of classroom instructions. Second, the scaffolding helped in clarifying the purposes of the research and kept the participating teachers on task. Third, since the Productive Pedagogies framework was a new concept to the participating teachers and to the Nigerian classroom, a two-day workshop was not enough for the participating teachers to learn all the principles and practice of Productive Pedagogies that were required to use as a tool to improve their practice. Therefore the scaffolding gave them the needed continual help and assistance on how to use the principles of Productive Pedagogies to improve their practice.

CHAPTER 5

DATA ANALYSIS 2: IMPLEMENTATION, REFLECTIONS AND CHALLENGES

5.0: Introduction

This chapter addresses three research aims as stated in Chapter 1. The first aim is related to the implementation of the Productive Pedagogies framework. The second aim considers the reflections of the participating teachers on their practice, while the third research aim concerns the challenges that the participating teachers encountered while implementing the Productive Pedagogies framework. Specifically, this section seeks to address the following research aims:

1. The changes in the participating teachers classroom practice as a result of the implementation of the Productive Pedagogies framework;
2. The participating teachers' reflections on the effect of the Productive Pedagogies framework on their practice.
3. The challenges that the participating teachers encountered while introducing Productive Pedagogies.

5.1: Implementing the Productive Pedagogies Framework

This section discusses specific activities that were developed by the participating teachers in their efforts to change their practice using the four dimensions of Productive Pedagogies. Specifically this section addresses research aim 1 above that concerns *the changes in the participating teachers' classroom practice as a result of the implementation of the Productive Pedagogies framework*. The discussion in this section is based on the following themes: First, the researcher discusses how the participating teachers used problem-solving strategies to achieve the Intellectual Quality dimension of Productive Pedagogies. Second, the researcher discusses how the participating teachers used collaborative problem-solving to encourage substantive conversation among students. Third, the researcher discusses how the participating teachers demonstrated how mathematics classroom problems could be connected to the world. Fourth, the researcher discusses how the participating teachers created an atmosphere of friendship and support to achieve Supportive Classroom Environment. Finally, the researcher discusses the strategies that were employed by the participating teachers to recognize the differences that existed among students and how the participating teachers used these strategies to achieve quality classroom teaching.

5.1.1: Using Problem Solving to Achieve Intellectual Quality

Problem solving is an important ingredient in mathematics classroom teaching. Data collected in this research suggested that the participating teachers explored problem solving to engage their students in solving highly intellectual quality problems. Jimmy, in Phase 2, specifically asserted that his objective was to make sure his students engaged in solving problems that are highly challenging. Jimmy stressed that,

> *I went to the class with the objective of getting my students solve problems that are highly challenging, so I could achieve Intellectual Quality teaching. (Jimmy: Casual Interviews: 2013)*

A similar comment was made by Jennie during Phase 1 of the research; she was of the view that achieving highly Intellectual Quality classroom instruction could best be achieved through effective problem solving. Jennie was of the view that,

> *Achieving Intellectual Quality requires mathematics teachers give their students challenging problems to afford them the opportunity to use their thinking abilities to analyse, criticise and synthesize their knowledge. This could be achieved through problem-solving techniques as this will also engage our students in higher order thinking, and substantive conversation to solve problems on their own. (Jennie: Reflection Meeting 1: 2011)*

From the researcher's observation in Phase 1 of the research, the participating teachers engaged their students in problem solving at each stage of the classroom teaching. For example, in cycles 2 and 3 the researcher observed in Jerry's classroom teaching that he always presented the problem and asked the students to discuss it first in their group before they attempted solving it.

> *I observed in Jerry's class that whenever there is a problem to be solved, Jerry will first ask the students to discuss the problem, and then solve it within the group, seek for assistance from other groups and finally give each group the opportunity to defend their solution before the members of the class. (Research Journal: 2011)*

This assertion was also observed by the students and mentioned during focus group discussion in Phase 1 of the research; Michael was of the view that the teachers gave them the opportunity to attempt the problems in their groups before helping them where necessary.

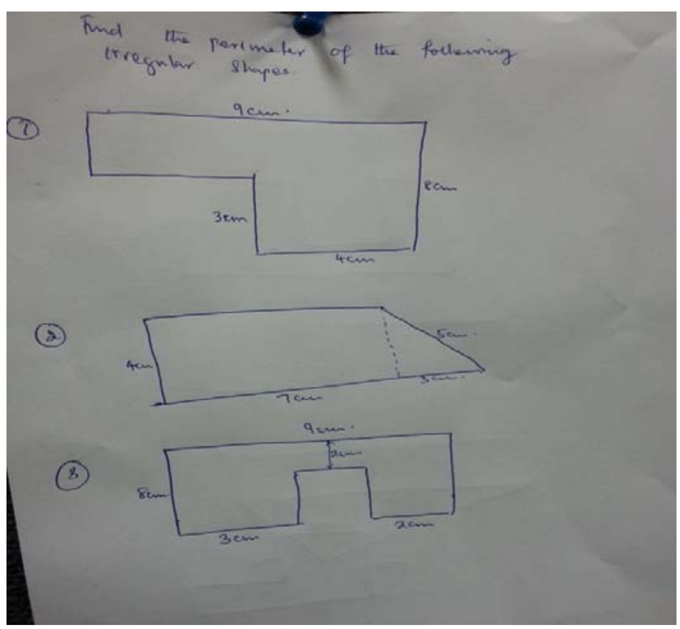
> *The teacher writes the question on the board and asks us to solve it in groups first…, to some extent he allows the student to try the problem first…, and that is good and it helps us. (Michael: Focus Group 2: 2011)*

A similar comment was made during my interaction with one of the students during Phase 2 of the research. The students were of the view that the teachers encouraged them to work independently and only helped when the students are frustrated. Notes from the Research Journal suggested that,

> *The approach was good and interesting…, the teachers group us to sit together to solve mathematics problems…, it was very interesting and easy for us because we did the work on our own without the unnecessary interference from the teachers…, they only assisted us on the board and when they discovered that we were helpless…, (James: Research Journal: 2013)*

In demonstrating how the teachers used problem solving in their classroom teaching an example of what happened in Jerry's classroom could be a good example. He attempted to convey knowledge and skills to his students (aged 14 years old) on the topic "*Calculation of Perimeter of a Given Shape*". Using group-work, Jerry exploited problem solving as a tool to achieve substantive conversation, higher order thinking and knowledge as being problematic.

> *I entered the class and walked to the back and sat down to observe what was happening in the class. Jerry had successfully introduced the perimeter of different two dimensional shapes to his students. He had also demonstrated this by solving some examples in the class and he asked if the students understood what he was explaining and the students responded positively. He then gave them three problems to solve. (See diagram below)*



He had initially organised the class in five groups of six students each and hence asked them to cooperatively solve the problems in their groups. I observed that he walked around to observe what the students were doing and offered support where necessary. I also walked around in my curiosity to know what was happening in each group. I observed that the students did not find question one and two difficult, as the two questions involved mere lower order thinking skills and the students did not take time finding the solution to the two questions. However, from my observation, question three was technical and required the reconstruction of new knowledge in order to achieve the required solution. The question required the students to find the perimeter of the shaded portion inscribed in an irregular shape. Jerry also observed the same and hence gave them more time and suggested they intensified and expanded their dialogue within the groups to other groups.

In my observation from group to group, I discovered in two of the groups that the students had identified different approaches to the solution of the problem, the first group reconstructed the irregular shape into a big regular rectangle and found the perimeter of the rectangle and also found the perimeter of the unshaded part of the rectangle, and the difference found between the two shapes to get the perimeter of the shaded part. The second group also reconstructed its own irregular shape by creating smaller but regular shapes from the initial irregular shape given and found the perimeter of each shape and sum-up the perimeters of all the shapes to get their own shaded part. I became interested in what they were doing hence I compared the two answers when the two groups presented their results to the whole class and discovered their answers were the same and correct. Feedback was given to the students by Jerry and he commended the two groups for their wisdom. At the end conversions were held especially to help the groups that were not able to successfully solve the problems. I also observed despite defending their solution openly some students still approach these two groups for further explanations. (Research Journal: 2013)

In this scenario, Jerry created activities that required knowledge as being problematic because the students came up with different approaches to the solution of the question given to them as shown in the observation above. Similarly, for the students to have reconstructed the question in their own understanding and come up with an appropriate solution to the questions, different from the general approach introduced to them by their teacher, demonstrated that the students used their higher order thinking skills and deep knowledge. The researcher stressed in the research Journal that,

> *I discovered in two of the groups that, the students had identified different approaches to the solution of the problem…, I became interested in what they were doing hence I compared the two answers when the two groups presented their results to the whole class and discovered their answers were the same and correct. (Research Journal: 2013)*

These were not easy tasks for the majority of students as it was not part of their normal classroom routine. It has been discussed in the literature that students depend mostly on teachers' examples to solve their problems especially in Nigerian mathematics classrooms where the teacher claimed the monopoly of knowledge. Finally the scenario also demonstrated that Jerry encouraged substantive conversation among the students. He had noted during the reflective interview that,

> *Effective students' conversation could aid students to use their higher order thinking to solve highly Intellectual Quality problems. (Jerry: Casual Interview: 2013)*

Jackson made similar comments also during his reflective interview:

> *I want to say from experience…, a teacher needs a lot of students' engagement to achieve substantive conversation; you also need a lot of substantive conversation to achieve higher order thinking, deep understanding and knowledge as problematic especially when highly Intellectual Quality problems are given. (Jackson: Casual Interview, 2013)*

The comments made by one of the students in Phase 1 of the research also supported collaboration among students and asserted that it focused students' solution to their problems.

> *This is not only you alone thinking on how to solve a particular problem, the thinking is in a group, by the time we join our heads together and think on a solution to a particular mathematics problem, you bring your idea… I bring my idea…, the solution becomes easier. (Julie: Focus Group 3: 2011)*

5.1.2: Collaborative Problem Solving

Substantive conversation is an element of Intellectual Quality that demonstrates the sustained interaction that exists between teachers and students and between students during mathematics classroom teaching. Data collected from the participating teachers demonstrated that substantive conversation is pivotal to solving highly Intellectual Quality problems. Part of this was demonstrated in Section 5.1.1 when Jackson asserted that:

> *Students need a lot of substantive conversation to solve highly Intellectual Quality problems that required higher order thinking, deep understanding and knowledge as problematic. (Jackson: Casual Interview, 2013)*

For example, Jackson was teaching Senior Secondary School 1 (age 14-15 years old) mathematics. This was a science class compared to the mixture of arts and social science students in Jerry's class. As a result, the students were better academically than the students in Jerry's class; however the students had a problem; they tended to prefer an individualistic approach to learning than the collaborative approach intended by Jackson. Therefore he complained,

> *My students…, though good and intelligent…, but…, they tend to work independently as against the collaborative classroom learning that I encouraged them to do. When I give them problems to solve before you know they have finished solving the problems independently…, introducing them to substantive conversation looks too complex to me…, and I feel to them it is a waste of time. (Jackson: Casual Interview, 2013)*

Jackson was teaching very good students and by Nigeria standard, high achieving students are always advised and encouraged to be in the science class, while the arts and social sciences takes the average and low achieving students. Jackson wanted to use these potentials to encourage substantive conversation among his students, but the students were in tune with their traditional individualistic approach to learning. Hence the researcher, through scaffolding, advised Jackson to introduce highly challenging problems that go beyond the classroom syllabus for Senior Secondary School 1 students.

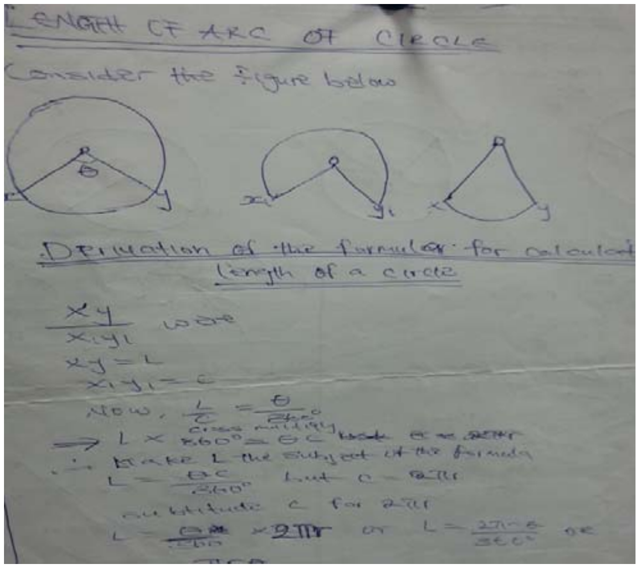
Give them challenging work that will force substantive conversation among the students. (Research Journal: 2013)

It was with this view that Jackson entered the class with the topic on *"The Length of an Arc"*.

I entered the class and the students were already seated, Jackson was at the chalkboard ready to start his lesson. In his characteristic way, I observed he first reviewed the previous lesson within two to three minutes and appropriately linked the previous lesson with the present. He then asked the students to draw a circle for him on the chalkboard. They were also asked to indicate the diameter, the radius and so on…, after some explanation of the properties of the circles he then asked the students to derive the length of an arc using the formula for calculating the circumference of the circle they had derived the previous day and also the properties of a triangle. I thought Jackson was joking…, looking at the calibre of the students he was working with, and knowing that most mathematics teachers avoid asking their students to do so. I also remembered I had advised him the previous day to provide highly Intellectual Quality problems to the students. Hence I watched to see what would happen next…,

I observed that the students were confused…, the problem was highly challenging …, subsequently, he raised some questions relating to circumference, angles, properties of a circles, triangles…, etc. He then asked the students to interact within their groups…, and he moved round and gave them some clues to the solution through question and answer techniques without really telling them what to do. I also moved around to observe what the students were doing in the groups. The students started grasping the clue, I also observed that this forced the students to be engaged in intensive dialogue within their groups…, he encouraged them further by suggesting they could seek assistance from other groups…, (within and outside their groups) substantive conversations within groups were intensified, the class became interactive, dialoguing, while negotiations, debates and collaborations were intensified among the students. The teacher further assisted through asking them further questions like what is the circumference of a circle. Can you remember the formula for finding the circumference of the circle? Now what do you do when you are calculating the perimeter of a shape? What is the sum of the angles in a circle? How do you calculate the perimeter of a triangle? And some other thought provoking questions that helped the students to derive the length of an arc.

After much deliberation within the groups, the students were able to come up with the formula for calculating the length of an arc. After they had all derived the formula in their groups; the teacher made each group to present their findings and share their results with the rest of the class. (Below is a sample from one of the groups). The teacher provided feedback for students…; further discussion on the formula helped or aided deeper understanding among the students. At the end of the class, questions were *asked and Jackson and the students interacted on the questions raised by the students. Jackson achieved his objective…, the class was interactive…., as substantive conversation between students was achieved. Subsequently, the students started feeling that when they worked together ideas are shared. (Research Journal: 2013)*



The observation above demonstrated Jackson's attempt to achieve a substantive conversation, as the students had earlier stuck to their traditional way of learning. Being good students, they tended to believed that they did not need others to succeed. However after this activity the students' views toward learning began to change. This was also demonstrated in the observation above when the researcher stated that,

The students started feeling that when they worked together ideas are shared. (Research Journal: 2013)

This student said after the conclusion of Phase 1 of the research that;

To me I like this type of approach…, because before I prefer working on my own…, this is because I sometimes want to contribute something but I feel that what I will say will not be correct and others might laugh at me…, but the teacher made us feel that what we felt were mistakes or wrong might end up being the idea the class is looking for to move forward. (Research Journal; 2013)

Jimmy also observed in his own classroom teaching that;

> *My students began to feel that arriving at a particular solution to any mathematics problem is not the issue…; the main issue is their understanding of how and why such a solution was gotten. (Jimmy: Casual Interview: 2013)*

Similarly, this challenge had earlier been raised in Phase 1 of the research by Jennie; she observed that sometimes high achieving students' make classroom teaching difficult for the teacher as they tend to show they know more than others. In her observations, the students attempted demonstrating this in Phase 1, but as the teachers changed their approach and strengthened their pedagogies in subsequent cycles, the students discovered that collaboration through substantive conversation helped improve classroom participation.

> *The high achieving students in the class in cycle 1 were trying to show that they knew it all, but in cycle 2, they were gradually coming down to work with other students. (Jennie: Reflection Meetings 2: 2011)*

Supporting Jennie, Jackson was of the view that collaboration through substantive conversation makes learning interactive and cooperative compared to the traditional competitive learning that prevails in most Nigerian mathematics classrooms, he noted that:

> *That is true Jennie…, the students started seeing learning as being interactive, and cooperative rather than it being competitive. (Jackson: Reflection Meetings 2: 2011)*

Jennie went further to state that substantive conversation improves student-student relationships.

> *Student-student relationships improved during substantive conversation, as one can really see the students interacting with one another and sharing ideas among themselves. (Jennie: Reflection Meeting 2: 2011)*

While Jerry was of the view that students achieved more when they learnt to work together as a group; he said,

> *Together we achieved more. (Jerry: Casual Interview: 2011)*

However, based on observation of the classroom practice of the participating teachers in both phases 1 and 2 certain elements of intellectual quality were either not properly implemented or completely absent. For example, the concept of metalanguage was not properly understood. Hence they found it difficult to really identify its existence of it during their classroom teaching. The perception of the participating teachers was that metalanguage had to do with difficult words in mathematics and it was sufficient if the teachers are able to explain these difficult words to the students. For example in Phase 1, one of the teachers was of the view that:

> *There was this case that required explanation of some difficult concepts in the topic he treated; he tried explaining them to the students though not really well…, this could be viewed as metalanguage. (Jackson: Reflection Meeting 2: 2011)*

In cycle 3 Jackson again observed:

> *Since the teacher had no difficult words to explain during his classroom teaching especially in cycle 3 there was no need for Metalanguage. (Jackson: Reflection Meeting 3: 2011)*

However, Jennie argued that:

> *Metalanguage is not only about difficult words, it also involves the re-explanation of what had been said before which the students did not understand. He also made some definitions of terms, so the Metalanguage was there during his classroom practice. (Jennie: Reflection Meeting 3: 2011).*

Similarly, from the data collected, the participating teachers had varied opinions on the implementation of metalanguage. Some were of the view metalanguage was partially implemented, while others were of the view that it was not implemented. The comments made by some of the teachers suggest that they had limited understanding of what metalanguage actually means.

> *There was improvement in almost all the elements of Intellectual Quality. However metalanguage was totally absent, though I feel there was no need of it in the lesson as the class was a revision class. (Jackson: Reflection Meeting 3: 2011)*

Jackson's point of view above shows that there was no application of metalanguage in this teacher's class because there was no need for its implementation. However, Jennie was of the view that there were cases of metalanguage in the teachers' classroom practice, because according to her metalanguage goes beyond the mere explanation of difficult words, it could be definitions of terms which could be axioms, theories, laws, etc. This suggests that Jennie had a better perspective of the concept of metalanguage.

> *To me he implemented all the elements in his dimension very well including metalanguage, since metalanguage is not only about difficult words, it involves definitions of terms, re-emphasis of difficult words, retreating to explain…, so the Metalanguage was there during his classroom practice. (Jennie: Reflection Meeting 3: 2011)*

Jerry supported Jennie, but, however, opined that, it was not well implemented.

> *I agree with Jennie but he needed to improve on the usage and application of this metalanguage, because it was not really well implemented. (Jerry: Reflection Meeting 3: 2011)*

The interactions between the teachers on metalanguage suggest that the teachers did not really have an agreement of the concept of metalanguage and its implementation. Perhaps the teachers had limited understanding of the element and its application to mathematics and indeed mathematics classroom instruction. Probably, the little discussion in the mathematics education literature on metalanguage could have also led to their misunderstanding of the concepts and its application to mathematics classroom instruction.

Similarly, the current secondary mathematics curriculum in Nigeria and perhaps around the world does not focus much on terms such as theorems, axioms, laws etc. They tend to dwell more on applicative mathematics at this level. This could have also been the cause of the misapplication of the meaning and implementation of metalanguage in the participating teachers' classroom instruction. Finally, perhaps it tends to support the views of some people on Productive Pedagogies who held the view that metalanguage is good for subjects like social studies and other arts and social science subjects (Alsharif, 2012). In view of all these assertions and assumptions, it does not imply that metalanguage is not important to the mathematics classroom and therefore could be discarded or cannot be implemented.

5.1.3: Connecting Classroom Mathematics to the World

Making mathematics relevant to students is a big challenge for many mathematics teachers, especially in Nigerian mathematics classrooms**.** Most mathematics classroom teaching in Nigeria, apart from being traditional in approach, sometimes focuses on algorithms and procedures with little emphasis on students' understanding and applications. This was one of the challenges raised by the participating teachers during the workshop. From their views,

> *The absence of teaching facilities makes it difficult for mathematics teachers to make their mathematics teaching real and practical. (Jerry: Workshop: 2011)*

Perhaps the participating teachers failed to realise the need for improvisation in mathematics classroom teaching. They also failed to realise that there are many other teaching facilities or instructional materials around the teacher that they could explore to make their mathematics classrooms real and practical to their students.

In Phase 2 of this research, Jackson introduced the concept of mensuration to Senior Secondary School 1 students. As an experienced mathematics teacher he simply brought improvised teaching resources to the class and made use of them to introduce the topic he was to teach. From the researcher's observation of Jackson's classroom the students who were also science students made use of relevant teaching resources around them to demonstrate the concept Jackson wanted to introduce. The researcher observed:

> *I entered the classroom and observed that Jackson was already at the chalkboard. This was his first lesson for the research. He had taken his time also to arrange the students in groups. However I noticed different objects on the teacher's table and I wondered what he wanted to use them for. He then started by raising the objects one after the other using the question and answer conversational approach. He was asking the students to identify the shapes of the objects he raised up as shown in the activity bellow:*
>
> *Teacher: (Brought out the first item) and then asked "what is this?*
>
> *Jenifer: Match box:*
>
> *Teacher: What mathematical shapes can you identify from the match box?*
>
> *Jenifer: This looks like a rectangle…, yes…; the surface is a rectangular shape sir…,*
>
> *Teacher: That is good he lifted up the second object and also asked "What is this"?*
>
> *James: This is a cube…, No a maggi cube…; but…, all sides are equal…, is a shape of a cube sir…,*
>
> *Teacher: What two dimensional shape can you identify from this shape James?*

James: This is a shape of a square…, a square has four sides equal…., yes the surface is that of a square sir…,

The teacher brought other objects and the students were able to identify the shapes. From my observation the students on their own without the teacher asking further questions started looking around seeing different objects around the class and identifying their shapes like rectangle, square, triangles and circular objects as circles. This implies that the attention of the students shifted from the objects the teacher brought to class to objects found around the class. Jackson asked them to classify the objects that they had identified within their environment into the basic shapes they already know. As I walked around I observed that the students were able to use the surfaces of their tables, chairs, floor, the wall of their classroom, to described rectangular shapes, others drew the chalkboard and named it rectangle and some uses the stand of their tables to identify the triangles; while others went as far as drawing a trapezium, rhombus and parallelogram using their previous background knowledge of shapes. Jackson and the students were able to use the shapes drawn in their books to identify the different types of two dimensional shapes. With this understanding Jackson wrote the topic on the board "Mensuration". Even though this activity did not last for more than 10 minutes, Jackson was able to demonstrate connectedness to the world around them. (Research Journal: 2013)

From the activity above Jackson was trying to demonstrate Connectedness to the world. This activity provided opportunities for his students to relate different objects found in the class with the concept of two dimensional shapes. Similarly, the activity helped students' self-discovery because from the activity the students were not only able to use the objects the teacher brought to the class but also identify more objects around them and relate them to different two dimensional shapes. Finally, from this activity the teacher was not only able to achieve Connectedness to the world but also was able to achieve students' background knowledge. The students used their previous knowledge of shapes to identify more shapes in the class; the researcher observed;

As I walked around I observed that the students were able to use the surfaces of their tables, chairs, floor, the wall of their classroom, etc. to describe rectangular shapes, others drew the chalkboard and named it rectangle and some used the stand of their tables to identify triangles; while others went as far as drawing a trapezium, rhombus and parallelogram using their previous background knowledge of shapes. (Research Journal: 2013)

Another example used to demonstrate connectedness to the world was from the classroom teaching of Jennie in Phase 1 of the research. Jennie was to teach Senior Secondary School 2 students the concept of sequence. This was a revision week and she needed to revise her topics before examinations the following week.

> *I stood at the window of the class and observed what Jennie was teaching. Her topic was "Revision on Sequence". She initiated activities that involved questions and answers techniques between her and her students. She started by saying…,*
>
> *Teacher: What is a sequence?*
>
> *Jane: Sequences are numbers that are arranged with specific patterns or intervals with specific rules guiding them*
>
> *Teacher: That is good; sequences most have a uniform pattern or rules guiding them. Can we mention some events we know that are sequential in our community or that suggest the idea of sequence as defined by Jane? Remember it must have a pattern and there must be a rule guiding it.*
>
> *Julius: Eating of food is in a form of a sequence.*
>
> *Teacher: Can you explain the pattern and the rule guiding it?*
>
> *Julius: When you eat let's say at 7am in the morning, you may not eat until 12 noon then 7pm that is a sequence.*
>
> *Jennifer: I don't think the idea of Julius is correct…, that is not a sequence…, people eat at different intervals. There is no rule guiding our eating;*
>
> *Teacher: Ok who then can give a better example?*
>
> *Jeremy: Changes in age:*
>
> *Teacher: Give us the interval or pattern and the guiding rule.*
>
> *Jeremy: If I and my friend were born the same day, the following year we will both increase by one year. Also all changes in our body are changing in the same pattern*
>
> *Jonah: No…… it's not possible the rule is not always followed…,two people could be born the same day one is tall and another is short…, supposing you were born the same day with a girl…, (laugh)…, changes in your body and hers are not the same…, for example…., (laugh…, the whole class also laughs along)….,*

Teacher: The increase in the number of years could be seen as sequence but in terms of growth and development the pattern does not always follow; that is true Jonah.

James: If someone is sick and goes to the hospital…, the doctor prescribes drugs…, the doctor always tells the patient the sequence or the intervals the drugs would be taken, that is a sequence…,

Jane: Yes…, that is a better example…., (the class also concurred in chorus)

Teacher: Ok… ok… can James identify the pattern or the rule guiding your sequence?

James: The rule is that the doctor might decide to say take two tablets of the drugs every four hours. That is the rule the sick person must follow. …, if the person is not educated, doctors always say, one in the morning, one at noon and one in the night… that is a pattern given to uneducated people.

The teacher then used the ideas to link to the topic. Since it was a revision class, Jennie then gave them some mathematics problems to solve. Before solving the problems she asked the students to first identify the pattern, the rule and the interval and explain the reasons for their decision. (Research Journal: 2011)

From the classroom interaction between Jennie and the students, it was observed that Jennie was trying to connect what the students know about events that take place sequentially with the topic sequence. She used the students to identify these sequences and the students were able to make some suggestions using their background knowledge of events that take place in their society. This demonstrated connectedness to the world. Jennie during the reflection meeting had commended Jackson for using students to cite examples of real life happening in the society. Her action in the activity above in cycle 3 demonstrated that she appreciated her observation of what happened in Jackson's classroom teaching in cycle 2. This is what she said:

The teachers (Jackson) most a times will make use of the students to cite examples of daily happenings in society. Activities like going to the markets to buy things, students in the football field and generally things around the

> *students were used to connect the lessons to the world. (Jennie: Reflection Meeting 2: 2011)*

However, there were limitations to these activities; the first of these limitations was what the researcher called “lower order thinking”. The activities did not pose any challenge to the students because the content of the activity was meant for students in Junior Secondary one or two. Perhaps, one may argue that this was Jackson’s first class with the students and as such he might not have had the basic knowledge of their abilities. Notwithstanding that, as a mathematics teacher at Senior Secondary School level in Nigeria, it is expected that he must have had enough knowledge and understanding that science classes in Nigerian secondary schools are mostly regarded as classes with high achieving students. In defending his action Jackson was of the view that he felt that the students from the school were students from poor socio-economic background and could not be given content that was far above their abilities; he argued:

> *Because of the level of these students I mean students from low socio economic background and from the semi-urban society like Kafanchan, one cannot compare their abilities with the students in Bauchi who are from an urban society and from a better and higher socio-economic background. (Jackson: Casual Interview: 2013)*

Perhaps Jackson has fallen into the trap that many teachers in mathematics are likely to fall into which is contrary to the very basis of Productive Pedagogies. One of the principles of the Productive Pedagogies framework is that teachers should not attempt to decide on the quality of what the students are to learn because of their socio-economic status, gender or learning abilities.

Another limitation to these activities is the fact that Jackson was not able to effectively connect the activity with the topic mensuration as expected in the curriculum. Mensuration in its literal meaning is the study of measurements. This is generally used where geometrical figures are measured to determine various physical quantities such as length, area, and volume. He had successfully enabled the students to identify objects in the class and also the samples he had brought, but failed to effectively connect to the topic he was teaching.

The next problem which the participating teachers identified especially in Phase 1 was the fact that there were topics in mathematics that they found difficult to make connections to the world particularly making high level connections to the world. One such topic was reflected during the mathematics classroom practice of Jackson. According to the participating teachers, they observed that Jackson had problems relating the concept of the development of the quadratic formula to the world. Therefore the teachers were of the view that there was no way that the development of quadratic formula could be related to the world.

However they supported the fact that Jackson was able to use knowledge integration and students' background knowledge to develop the quadratic formula. This he did by using the ideas of completing the square method to introduce the quadratic formula; According to the participating teachers he was able to achieve the elements of knowledge integration and students' background knowledge. The researcher observed and noted in his Research Journal that:

> *While the major problem that the students raised that the teacher's work was abstract, there was no way he could have related the derivation of quadratic formula with the world. He was just in the class to develop the formula. How do you relate the quadratic formula with the world? Ask one of the students? (Research Journal: 2011)*

The comments above suggest that the development of a quadratic formula is purely theoretical and cannot be related to the world. However from the analysis above, one may comment here that not in all cases were participating teachers not able to implement connectedness to the world in their teaching; there were situations where they were able to demonstrate connectedness as shown above.

Still on Connectedness, another example that presented a better application of Connectedness was seen in the classroom teaching of Jerry. For example, Jerry wanted to introduce the concept of perimeter to his Senior Secondary School 1 students. He created an activity that was based on students' background knowledge.

> *I entered Jerry's class…; it was his second lesson with his Senior Secondary School 1 students. Jerry wanted to introduce the concept of perimeter of regular and irregular shapes to his students. In introducing his lesson, he started by revising what he taught in the previous class which is the identification of different shapes. He then went further to create an activity where he asked four students to stand at the four corners of the class. He gave the first student an improvised baton and asked the student to run and give it to the second student, then to the third and then to the fourth student. The students ran round the class and brought back the baton to the teacher. He then asked the class*
>
> *Teacher: What where these students doing?*
>
> *Jamil: They were running a relay race..., but..., what has this to do with mathematics?*
>
> *Teacher: The teacher answered the student…., then asked…, who can tell me how long did these students run?*
>
> *Bosam: It is not possible sir, we have to measure…., or ... can we use ruler to measure the distance they covered?*
>
> *Teacher: You are right we could…, but….*
>
> *The teacher stopped there, and went further to ask more questions and the students responded positively; from the questions he asked led to the topic of perimeter. The students through self-discovery were able to see perimeter as the distance round a given shape…, He further sketched the shape of the class showing the four students at different points in the shape. From my observation I expected Jerry to ask the students to use either their feet or the metre ruler that was in the class to measure the distance each of the students ran as suggested by Bosam, but even though he did not use that he did something similar; he asked the students to estimate the length in metres that each of the students ran. The students looked at the different distances each student ran and suggested the distance covered. (Research Journal: 2013)*

From the observation above it demonstrated that the teacher was able to use the student's background knowledge to make connection with the lesson he intended to teach. Here, the researcher observed how the participating teachers created activities that helped students make links between the mathematics they are learning and their background knowledge and between mathematics and other subject area such as physical and health education.

This demonstrated a better application of Connectedness; not just because the teacher was able to apply two elements of Connectedness but it helped the students to learn mathematics using real life applications or events that are very familiar to them. However, from the observation above, the teacher could also have achieved Connectedness to the world if he had asked the students to use their feet to measure the distance in feet round the class or better still use the chalkboard ruler as suggested by one of the students to measure the dimensions of the class. The student said,

> *It is not possible sir, we have to measure…., or … can we use ruler to measure the distance they covered? (Jamilu: Research Journal: 2013)*

He, however, chose to ask the students to estimate the distance covered by each of the four students. This could perhaps be viewed as using the students' higher order thinking but the teacher denied the students the opportunity to see the way lengths are measured.

In defending his approach at the end of the lesson Jerry was of the view that asking students to use their feet or meter ruler to measure the distance covered could amount to lower order thinking. He was also of the view that in achieving highly challenging and quality classroom teaching the teacher requires creating in students the act of critical thinking. He said,

> *First, I wanted my students to think critically, make good judgement through estimation of the distance each student ran. Secondly, asking Senior Secondary School students to measure a class does not suggest giving students challenging classroom activities to do. That is meant for pupils in primary five or worse still Junior Secondary School students. Not Senior Secondary School students who are preparing to write the national exams; they needed something higher and challenging. (Jerry: Casual Interview: 2013)*

In Jerry's effort to achieve Connectedness and improve the understanding of his students on shapes, Jerry attempted establishing the relationship between shapes and shapeless objects. He was surprise to observe that his students were able to identify and establish relationship between objects that have shapes and those without shapes. To Jerry's amazement his students were able to demonstrate knowledge integration. They were able to establish the relationship between shaped objects and shapeless objects. Jerry opined,

> *Surprisingly, when I asked the students "are there objects in our societies that have no shapes?" The students came up with a beautiful discovery that demonstrated Connectedness in my class; they identified Amoeba in Biology, and others said liquid substances in chemistry as objects having no shapes. They occupy the shapes of their containers. This is an example of knowledge integration. They did that with all zeal and enthusiasm. (Jerry: Casual Interview; 2013)*

Generally and traditionally, mathematics teachers, and indeed all teachers, believe that a good teacher is the teacher who can arrange the content of what he or she teaches sequentially, that is from the known to unknown, from simple to complex and from what the students already know to what the students need to know. This was demonstrated by all the participating teachers at each stage of this research. The data collected demonstrated that the participating teachers made an effort to explore this element in their classroom teaching. For example, in the first reflection meeting, Jerry was of the view that effective teaching should begin from simple to complex:

> *In my own opinion…, as far as teaching is concerned…, the teacher is supposed to start it, from simple problems to complex ones. (Jerry: Reflection Meeting 1: 2011)*

During a focus group discussion, Julie made similar assertions about quality classroom teaching. In her view if teachers want their students to understand their lessons they have to take things gradually. Julie's definition of gradual teaching was given as the teaching that progresses from simple to complex. She said:

> *I think things had to be taken gradually for students to understand. I think it's best to work gradually so that students can really follow what you are doing…, one has to start from the simple and progress to the complex, so that you don't lose your students' interest. (Julie: Focus Group 1: 2011)*

The participating teachers explored students' background knowledge to improve their teaching. The researcher's observation of most classroom teaching of the participating teachers suggest that at the beginning of each day's lesson the mathematics teachers usually spent some time to revise the previous day's work and link it to the present topic to be taught. However, students' background knowledge is not restricted to the revision of the previous lesson; it has to do with relating real life problems to the students' new knowledge. For example in Section 5.1.2 (*The Length of an Arc*) the researcher observed in Jackson's classroom teaching that:

> *In his characteristic way …, he reviewed the previous lessons within two to three minutes and appropriately linked the previous lesson with the present. (Research Journal: 2013)*

On the benefit of Connectedness, Jennie suggested that when mathematics teachers make appropriate Connectedness in their classroom teaching, it attracts students' interest to the classroom activities and aids students' understanding to the topic:

I think making connection of the mathematics we teach students with the world around them as seen in Jackson's classroom attracts students' interest in the mathematics we are teaching and helps improve not just their interest in our teaching but their understanding. (Jennie: Reflection Meeting 2: 2011)

Similarly, Jerry commented during a Casual Interview in Phase 2 of the research that Connectedness makes mathematics classroom teaching real and practical and attracts students' interest and participation to his classroom teaching.

There were certain things I did which demonstrated Connectedness…, I asked my students to identify different shapes they could find in the class. The students were interested and happy to see mathematics relating to things around them…, they identified rectangles, triangles and squares using the chalk board, their desks and many other different shapes found in the class. This made my teaching real and practical; it also attracted my students' interest and participation. (Jerry: Casual Interview: 2013)

5.1.4: Atmosphere of Friendship and Support

Supportive Classroom Environment is instrumental to effective classroom teaching. If mathematics teachers made an effort to create classroom environments that are supportive and engaging to their students, students' participation and engagement in mathematics classroom activities would also increase during classroom teaching. Data collected during the research demonstrated that the participating teachers in Phases 1 and 2 of the research created a Supportive Classroom Environment suitable for effective teaching and learning.

From the researcher's observations of the participating teachers' classroom instruction, there was evidence of support being demonstrated either by the teacher or through their students during classroom instruction. For example, in Jackson's classroom, the researcher observed that when the problem was challenging to the students the teacher provided support to them, and encouraged his students to seek and provide support for one another. In particular, in Phase 2 the researcher observed in one of the problems the students were solving that:

> *I observed that the students were confused…, the problem was highly challenging …, subsequently, he (Jackson) raised some questions relating to circumference, angles, properties of a circles, triangles…, etc. and he moved round and gave them some clues to the solution through question and answer techniques without really telling them what to do. The students started grappling with the clue, I also observed that this forced the students to engage in intensive dialogue within their groups…, he (Jackson) encouraged them further by suggesting they could seek assistance from other groups…, (within and outside their groups)...,*
>
> *The teacher further assisted the students through asking them questions like what is the circumference of a circle. Can you remember the formula for finding the circumference of the circle? Now what do you do when you are calculating the perimeter of a shape? What is the sum of the angles in a circle? How do you calculate the perimeter of a triangle? And some other thought provoking questions that helped the students to develop the idea of the length of an arc. (Research Journal: 2013)*

The observations of Jackson's classroom by the researcher clearly demonstrated that the participating teacher used support to help his students find solutions to their classroom problem. This he did by using different forms of support. For example, first, the participating teacher moved around to see what the students were doing and offered support as stated. Second, the teacher used questions and answer techniques to trigger the collaborative thinking of his students. Third, another approach that the teacher adopted in the observation above was requiring the students to offer support to one another.

And the students demonstrated it by helping one another in the process to finding solutions to their problems. For example, in Jerry's class it was observed that the students sought help from other groups when they discovered the problem was too challenging for them.

I also observed despite defending their solution openly some students still approached these two groups for further explanations. (Research Journal: 2013)

This demonstrated that the introduction of the Productive Pedagogies framework in the participating teachers' classroom teaching created a new conducive and friendly atmosphere for students to learn mathematics. Jerry supported this in Phase 1 by saying,

When I introduced the Productive Pedagogies framework in my class, it naturally created a friendly classroom atmosphere between me and my students. (Jerry: Reflection Meeting 1: 2011)

Generally, mathematics teachers and students do not relate in a friendly manner in Nigeria. Experience suggests that most students do not only dislike mathematics, but they also dislike their mathematics teachers. However, according to the participating teachers and students there was an improvement when teachers created a conducive and friendly learning environment. This gave their students more trust and confidence to approach their mathematics teachers. They were not only able to ask their teachers questions, but they interacted freely and in a friendly manner with them. Jackson supported this idea by stating the reasons behind the improvement of the teacher-student relationships. He was of the view that this came as a result of the relaxed classroom atmosphere he had created during his classroom teaching. Jackson said,

My classroom environment was truly relaxed; hence, I created a friendly atmosphere for teacher-student and student-student interactions. (Jackson: Reflection Meeting 2: 2011)

Other benefits of using Supportive Classroom Environment of Productive Pedagogies framework included the following: students being able to have some control of their own learning in the class which helped the students to relax and participate in the classroom activities created by the participating teachers. Jennie argued:

> *The setting that makes mathematics teachers have the monopoly of knowledge and make students depend on the teacher for everything does not portray good picture of students' direction. But in a situation where we are teachers and we are students; makes our students relaxed..., the teacher brings the knowledge and the students analyse and discuss suggest students' direction. (Jennie: Reflection Meeting 2: 2011)*

It also helps the students gain some confidence and control over their learning activities. Jennie continued,

> *When the teacher brings the knowledge of what is to be learnt and the students analyse it to find solutions to their problems it tends to boost their confidence and encourage independent learning. This is against the background that students tend to depend on their teachers for all they need to learn. (Jennie: Casual Interview: 2011)*

A second benefit is that the teaching and learning is participative and collaborative rather than the usual teacher-centred teaching approach commonly demonstrated in Nigerian mathematics classrooms.

> *I observed that students' participation was more during my classroom teaching compared to the conventional classroom setting. (Jennie: Reflection Meeting 1: 2011)*
>
> *I observed that there was active participation of students in the groups; the students were busy interacting with one another in their groups on the topic. Interactivity in Productive Pedagogies is really good; it make teaching and learning more teacher-student friendly. (Jackson: Reflection Meeting 2: 2011)*

A third benefit was an increase in classroom conversation, between students and between students and their teachers. Jennie supported this by saying:

> *Students contributed to my classroom teaching…, there was good interaction between me and my students and between students which was not allowed in the conventional mathematics classroom. (Jennie: Reflection Meeting 2: 2011)*

5.1.5: Recognizing Students' Differences in Mathematics Classrooms

Identifying students' characteristics is one of the basic qualities of a good mathematics teacher. A teacher is expected, even in the traditional mathematics classroom, to identify the high, the average and the slow achievers among his or her students and meet their academic needs. In the Productive Pedagogies framework, Recognition of Difference goes beyond mere academic recognition; it rather includes social, cultural, emotional and psychological differences that exist among students in the class. Recognition of Difference is demonstrated when a teacher creates a classroom scenario that allows all members of the class to have equal opportunity to learning irrespective of abilities or disabilities. It is also demonstrated when a mathematics teachers encouraged representative participation of all students during classroom decision-making.

This is what the participating teachers did to demonstrate Recognition of Difference. The researcher attended both Jerry's and Jackson's classroom during Phase 2 of the research. Before the teachers started their classroom teaching, they first reorganized their classroom structures or the classroom settings to make sure their students were in groups. From the researcher's observation of both classrooms, the teachers made deliberate attempts to recognize the different social groups in their classes from the beginning of the project. In defending their action Jerry explains:

> *When we got to the class, we discovered that the students were sitting according to their identities- boys with boys; girls with girls- even among these students we discovered we had another problem, students from the same tribe or culture sat together and you found them interacting in their own language. You also found friends also sitting together. Therefore the only thing we did was to reorganize the class with the help of the mathematics teacher and the classroom captain since we did not really know the students…, and that really helped us create a more cohesive classroom*

> *atmosphere…, though they attempted resisting the approach…., we however succeeded is convincing them. (Jerry: Casual Interview; 2013)*

From the comments from Jerry above and his effort to achieved quality classroom teaching from the first day, both teachers reorganized their classroom seating arrangements and made the students sit in mixed groups; for example, in Jacksons' class, the following steps were taken to reorganize the class:

> *I followed Jackson to the class, being the first day of my classroom observations. The first thing he did was to discuss his mission with the students, and sought their cooperation with him throughout the research. The students also pledged their allegiance to him. He then discussed with the students the need to reorganise the class for their maximum benefit and participation. This he did by asking the students to sit in groups of five or six. The students were not comfortable with the idea of the new seating positions; he however explained his reasons and then persuaded them after which they reluctantly agreed. After setting the class to sit in groups, he also persuaded the students again in each of the groups to elect their group leaders and secretaries.*
>
> *Responsibilities of group leaders and that of the secretaries were given. This he did by explaining to the students that when a problem is raised in the class, the group leader will lead the group or appoint someone in the group to lead or solve the problems while the secretary notes all the deliberations and decisions reached in each group. From the groupings I discovered that boys and girls were made to sit together, this was actually the reason that the students demonstrated some resentment at the beginning. He also made sure with the help of the mathematics teacher of the class and the classroom captain that no two friends sat together. With the assistance of the mathematics teacher students with different learning abilities and/or disabilities were made to sit together. He asked the students to please interact together and make sure every member of the group knew what was going on as there would be times for defence of group solutions when he will call on anybody irrespective of ability or disability to represent the group. (Research Journal: 2013)*

From the observation by the researcher of the classroom activities during the first day, there were difficulties getting in students' cooperation in the activities in Jackson's classroom. The reasons for this perhaps was as a result of his students being generally good academically because they were from the science class and tended to prefer individualised learning as stated in Section 5.1.2.

Similarly, the students' upbringing also affected their perception of grouping strategies. This is because the school was a mission school, owned by churches and Christian religious organizations. In these types of schools religious discipline is highly upheld. Therefore any interaction that will bring boys and girls at this age together could be termed inappropriate. The researcher also interacted with students after the first classroom instruction. Their initial view was that they found it difficult believing that their teachers could encourage continued interaction between boys and girls. This student argued:

> *This is a mission school, the school authority is strict or firm against any male-female relationship, and we are made to believe that there should be some restrictions in our relationships. Therefore making us sit together…, talk together (though in groups) seems a new thing all together to some of us and indeed very strange…, but my first thought was that it might be distractive to the classroom teaching…, but it seems the teachers were very active and good…, we had no opportunity to do other things. (Jemila: Research Journal: 2013)*

A student from Jerry's class also made the same observation:

> *This was very strange…, I thought we have been taught that when problems are given in the class we should cover our work or we should not allow anybody to see what we are doing…, but asking us to work together looks strange…, sincerely to tell you the truth I initially felt this is morally wrong…, as if these teachers did not know that this is a mission school…, but our teachers were with them and supported it…, it was strange…, but as we progressed I discovered I learnt more from my colleagues especially as you know mathematics is a very difficult subject…, (laugh…,) (Jessica: Research Journal: 2013)*

These views demonstrated that the students initially felt this procedure was strange to them because they were accustomed to the traditional mathematics classrooms of individualized learning. A student in Jerry's class supported this when she said,

> *I thought we have been taught that when problems are given in the class we should cover our work or we should not allow anybody to see what we are doing. (Jessica: Research Journal: 2013)*

However, as the research progresses their views about the traditional and cultural mathematics classrooms began to change. From the researcher's observations and interactions with the students, the new classroom setting created by the participating teachers did not just happen. The participating teachers were prepared and had identified their areas of weaknesses in Phase 1. One of the students was of the view that the participating teachers strengthened their pedagogies and instead of the classroom being distractive, the teachers made them so busy that they did not have opportunity for distractions to occur in their groups.

The researcher's discussion with other students suggested that they appreciated this classroom approach and wished their mathematics teachers continued with it. For example from the researcher's discussion with a student in Jerry's classroom, this student was of the view that she wished that her mathematics teachers would continue with this classroom approach to teaching mathematics. The student said,

> *This grouping approach is good…, I wished my teachers continued with it; because since we started this work, we solved problems together in the class, in the hostel and even during prep in the evening…, I discovered mathematics is a bit easier when you work with your classmates than when you are alone. (Jamila: Research Journal: 2013)*

Another student from Jackson's classroom was of the view that,

> *The approach brings all students together to see a mathematics problem as a group problem not as an individual problem. The approach was very interesting, we sit in groups to solve the problems together, we worked on our own, without the unnecessary interference from our teacher…, the teachers assisted us on the board by simply explaining the basic formulas to us, how we approach the solution was left to us…, the teachers only come in to help when they discovered we are frustrated and that is good for us. (Jasmin: Research Journal: 2013)*

This was different from what happened in Phase 1. The school was not a mission school. There were no restrictions in the relationship between males and females students. The researcher observed that there was no resistance to the classroom setting of the participating teachers. The students willingly and happily cooperated with the participating teachers when they tried grouping the students. For example, my observations of all the classes taught by the participating teachers were that the students appreciated it. One of the students during the focus group discussion said:

> *We were fixed to sit in groups like in a circular form, and we were made to interact with one another in the group…, This sitting posture created by the mathematics teachers in our classes, tends to encourage slow learners; they were not left out, they were carried along. (Jane: Focus Group 3: 2011)*

5.1.6: The Multi-Cultural Nigerian Mathematics Classrooms

Nigeria is a multi-cultural society with over 350 different tribes and distinct cultures. Among these we have close to 1000 different dialects and/or languages. Therefore in a typical mathematics classroom, the mathematics teacher sometimes discovers that he or she is teaching students from different cultural groups. Therefore to adopt cultural knowledge and integrate it into mathematics classroom teaching sometimes poses a greater challenge for the teachers. This is because, what constitutes a recognizable way of life in one culture could be regarded as '"taboo" in another culture.

In view of these issues, the use of some illustrations by mathematics teachers during classroom teaching might be found to be making sensitive comments that could generate conflicts among students. For example, this student said during the focus group discussion that:

> *Like now, if you talk about rice, personally, I enjoy eating rice ..., If you talk of rice in a mathematics class for some one whot is addicted to rice like me…, my mind will click to it throughout the day…..that is what I will be thinking about …, you could lose my attention to the lesson. Another student may have*

> *the same view with me and may be offended…, and the teacher could also lose the interest of that student in the lesson. (Micah: Focus Group: 2011)*

However the researcher observed that the participating teachers explored these diversities among students to demonstrate the cultural knowledge during their classroom teaching and they used them to improve their practice. The researcher observed in Jennie's class that,

> *She was able to identify the sets of students in her class…; she started with an introduction… and she used it to group the students in her setting of the sitting arrangement in the class. This demonstrated cultural integration in the class, where the grouping Jennie did was not based on tribe or religion, as stated by one of the students during the focus group discussion, the students were scattered to sit with other students not based on the fact that this is my friend or not my friend…, she identified the sex or the gender of her students in the class, the gifted and the slow learners, those willing to learn and those not willing to learn. She was also able to adopt the question and answer teaching and learning techniques to meet the needs of these socio- cultural groups or multi-cultural groups in her class. (Research Journal: 2011)*

The researcher's interaction with the focus group students during the research suggested that the participating teachers were able to identify the different cultural groups in their classroom instruction and made efforts to manage them. For example in Phase 1 of the researcher Micah commented that:

> *There was cultural integration in the class, the grouping were not based on tribe or religion, the students were scattered to sit with other students not based on the fact that this is my friend or not my friend…, The teachers knew what they were doing …, they were able to make sure everybody was involved. (Micah: Focus Group 2: 2011)*

Observation of the classroom practice demonstrated that the students appreciated the effort of the teachers and cooperated. One of the students was of the view that recognizing and respecting students' cultural background tended to encourage classroom inclusion.

When the cultural background of the students is respected, it tends to make students feel included in the mathematics classroom. (Jane: Focus Group 3: 2011)

Another student also said,

The teachers recognise the different kinds of students in the class…, there was cultural integration in the class…, nobody feels inferior or superior, boys and girls were recognised and respected equally…, Every student's opinion was respected…, In the way the teachers were teaching the dormant groups among us were fully recognised and carried along. (Julie Focus Group 3: 2011)

Similarly, equity in this research refers to providing equal opportunities for learning, showing understanding and appreciation to all students of varied cultures in the development and provision of knowledge and understanding in mathematics classrooms. Data collected in this research demonstrated that the classes taught by the participating teachers provided this understanding. For example, in my observations of all the classes taught during Phases 1 and 2 of the research, the participating teachers gave particular attention to minority groups in the class. These minorities could be students with learning disadvantages, tribes, gender and cultural minorities. For example, the researcher observed in Jackson's classroom that after grouping the students he said to them,

Make sure you interact with one another, share ideas, and make sure whatever you know, say it out in the group so that other members of the group can learn from you and correct you if your idea is missing out. He went further to say if you have problems understanding anything simply ask the student next to you or you can also raise it up in your group so that you can jointly find a solution to the problem in the group. (Research Journal, 2013)

With this comment, the researcher later discovered that it helped some students in Jackson's classroom. For example, when the researcher interacted with the students after the class in Phase 2, one of them said, *To me, I like this type of approach…, because before I preferred working on my own…, this is because I sometimes want to contribute something I felt very reasonable in the class but there is this feeling that what I will say will not be correct and others might laugh at me…, but the teacher made us understand that, what we feel to be a mistake or wrong might end up being the idea the class is looking for to move forward. (Jasmin: Research Journal; 2013)*

Another student was also of the view that,

Grouping us make us identify some good things others know that we don't know…. I discovered we all worked with passion and involved everybody…, Whatever idea you have you simply say it and nobody said anything against it but rather your simple ideas are digested and help lead to the solution. (Jamilu: Research Journal: 2013)

Similarly, the researcher observed in Jerry's classroom in Phase 1 that after encouraging the students to share ideas and work together he challenged them to make sure all the students, irrespective of ability, knew how to solve the problem.

Each group must be ready to defend their solution, and I will pick anybody in your group to defend your group, so, make sure every member of the group knows how to solve the problem. (Research Journal: 2011)

From the comment of Jerry, the researcher observed that, working together makes the students motivated to be sure every member of the group is involved. Jane and Julie emphasised this during the focus group discussion in Phase 1. They were of the view that this approach encouraged the slow learners in the class as that made them serious and asked questions on how their problems could be solved:

The teacher really tried; he, like made sure everybody is carried along and should be able to solve the problem. And he made it clear to us that everybody in the group must make sure he is prepared to solve the problem because he can call anybody at any time to solve the problem. (Julie: Focus Group 2: 2011)

That is true Julie…, it made everybody sit up and make sure he understood because you don't know if you are going to be called to solve the problem on behalf of your group…, the groups also made sure everybody followed what was going on in the class so we could not disappoint the class… it was a good motivation on the part of the students. (Jane: Focus Group 2: 2011)

Another thing learnt from the research is the fact that minorities in most Nigerian mathematics classrooms have traditionally been disadvantaged. However, during this research, the participating teachers made efforts to address these challenges among the students. In my interaction with some of the students during Phase 2 of the research, a particular student showed concern about minority groups in the mathematics classroom. This particular student was among the older students in the class and showed her initial frustration when she approached younger students for assistance. In the researcher's interaction with this student she was of the view that the way the participating teachers handled the problem in her class and their approach to teaching helped address this problem and she was effectively integrated into the mathematics classroom. She said:

> *This method is good because it has helped remove this attitude of younger students making a mockery of the older students in my class. Before, you sometimes found it difficult to approach your classmates when you needed further explanation about something you did not understand, but the teachers made us work in groups and insisted everybody must be made to understand what is happening in the group…, learning is in groups and not individualistic as earlier viewed by younger students in my class…, for example sir, I am 17 years old, going to meet a students of 13 or 14 years could be demeaning and degrading to me…., from experience another older student was insulted by a younger student in my class the other day by calling the student "BIG FOR NOTHING". But this collaboration you are talking about I think is good as it will help us see everybody as important in the class. (Jessica: Research Journal, 2013)*

Observations of the participating teachers' classroom teaching demonstrated that their students were helped and assisted during the classroom teaching. Jackson was of the view that if mathematics teachers provided equal opportunities to all students so that students with learning disabilities will also be helped and assisted.

> *Provision of sufficient social support, equal access to mathematics learning resources, and provision of the enabling environment to the disadvantaged students in the mathematics classroom can contribute to the classroom*

participation of students with special needs. (Jackson: Casual Interview: 2013)

Similarly, looking at the general perspective about students with low socio-economic status in the class, gender and cultural differences; observation of the classroom setting of the participating teachers showed that they made provisions that reduced the effects of such issues. The participating teachers and their students made an effort to treat all students equally. For example, on gender the students were of the view that the participating teachers recognised female students as well. Janet in Phase 1 observed that,

> *The mathematics teachers recognised the presence of female students during their classroom teaching…, not that the boys were neglected…, but because the participating teachers recognized that we female students sometimes feel mathematics is for boys and not for girls…., As it is generally believed that boys are usually regarded as mathematics GURUS (meaning better mathematics students)…, while everybody believed that girls are always left behind…, But the teachers made us to understand that it is not true we females can do it also and even better, so we were encouraged…, similarly, seeing a female mathematics teacher among the teams teaching mathematics also made a world of encouragement on the part of the girls in the class. (Janet: Focus Group 2: 2011)*

Similarly, the high achieving students were given the opportunity to use their potential to help the slow learners and one of them was so happy during the focus group discussion and asserted that the most important thing in learning is the ability to help someone in need:

> *The joy of it all is that one makes a member of his class happy. I feel proud when I assist another student who needed my assistance…, I think I understand it better also when I help someone to solve a problem…, and you said it during the workshop sir. (Julie: Focus Group 3: 2011)*

Therefore, the concept of equity in this research described a situation where the participating teachers provided opportunities for students irrespective of gender, socio-economic status and abilities. These were also addressed during the classroom teaching of the participating teachers. For example, Micah (student) and Jennie (teacher) were of the view that the participating teachers make sure every student was recognized and involved:

> *Generally everybody in the class feels recognised and involved during the mathematics classroom teaching. (Micah Focus Group 2:2011)*
>
> *Productive Pedagogies makes everybody equal…, it's like we are teachers and we are all students. The teacher brings the knowledge and the students analysed and discussed. (Jennie: Reflection Meeting 1:2011)*

5.1.7: Summary

The analysis in this section was divided into seven sections which are related to the first research aim stated in Section 5.0. In Section 5.1.1 the researcher analysed the data that demonstrated the implementation of Productive Pedagogies. The following were observed from the analysis. First, the analysis demonstrated that the participating teachers adopted the problem solving strategy as a means to achieving and encouraging solving highly Intellectual Quality problems by students.

Second, the analysis also showed that, when students are given highly Intellectual Quality problems collaboration and substantive conversations are usually re-enforced among the students. This is because according to the analysis in Section 5.1.2 the students, especially the high achieving students, tended to prefer the individualised approach to problems solving to the collaborative approach. This was a great concern to the teacher; hence, he attempted to give the students challenging mathematics problems which forced substantive conversation among the students.

Third, the analysis also revealed that the participating teachers and their students made used of some improvised materials to achieved Connectedness. The study in Section 5.1.3 demonstrated that when instructional materials are not available, using locally made materials makes mathematics teachers use real life activities with their students. This usually helps make mathematics classroom instruction real and practical to the students. Still on Connectedness the analysis demonstrated that the participating teachers explored their students' background knowledge to make their mathematics real and practical to the students. However, the findings also suggested that the participating teachers had some limitations in implementing Connectedness in their classroom instruction. These limitations included providing students with lower order thinking materials, the inability to link the real life classroom instruction with the content being taught, and finally the teachers, particularly in Phase 1, found it difficult implementing connectedness to the world with abstract mathematics topics.

Fourth, the analysis demonstrated that an atmosphere of friendship and support was provided to the students. This kind of atmosphere helps in building students' confidence in approaching their teachers in solving highly Intellectual Quality problems. It also created in students the sense of belonging and responsibility not only to their learning but also to the members of the classroom community. It generated a sense of independence among the student because the teachers helped make them responsible for their own learning. This helps make their students take initiatives, risk and, to some extent, control of their classroom learning.

Finally, from the analysis, the study reveals that the participating teachers were able to use the different multicultural groups found in their classrooms especially in Nigeria with over 350 tribes. Differences of culture, religion and socio-economic status were well managed by the teachers. The teachers explored these as opportunities to achieve quality classroom instruction. Students' abilities and disabilities were also used as a spring-board to encourage collaboration among students during classroom instruction. Benefits of the activities created by the participating teachers were also revealed by the comments made by the teachers and the students on the effectiveness of the implementation of the framework in the class.

5.2: Teachers Reflection on Productive Pedagogies Framework

In Chapter 4, the traditional classroom teaching was discussed. In that discussion, it was noted that in cycle 1 the participating teachers initially had concerns on their role of using the Productive Pedagogies framework to improve their practice. They also argued that releasing classroom control and learning to their students could prove to be counterproductive to effective classroom teaching. Similarly, in the same chapter the researcher discussed the initial resistance put forward by the focus group students who were part of the workshop on the overbearing-authoritarian mathematics classroom environment created by the participating teachers. In this section the researcher discussed the reflections of the participating teachers or their views about the use of the Productive Pedagogies framework and how it helped them in transforming their traditional approach to classroom teaching to a more student-centred approach. Specifically, this section discusses research aim 3 which stated that: *to investigate the participating teachers' reflections on the effect of Productive Pedagogies framework on their practice.*

The researcher discusses the section using the following themes. First, the participating teachers initial scepticisms on the Productive Pedagogies framework on the possibilities of its effectiveness in reforming their classroom teaching. Second, the participating teachers' reflection on the benefits they obtained in implementing the Productive Pedagogies framework. Third, the unity the participating teachers observed on the dimensions of Productive Pedagogies, and finally, a summary.

5.2.1: Participating Teachers' Initial Scepticisms

When this research started the participating teachers greeted the idea with mixed feelings. Some were of the view that this is just another research project, others felt that there is nothing new or good that will come out of it, while others were indecisive. One of the initial comments raised by one of the workshop participants was:

> *Sir, in education, if one is dealing with human beings in the area of teaching-learning one have to be careful. Now, as you know there are so many methods of teaching and learning that people are coming out with today which have not really helped the system. Is this Productive Pedagogies framework a saviour to the teaching learning problems we have with our students in Nigeria today? (Jackson; Workshop: 2011)*

However, despite these reservations, the researcher and the participating teachers kept faith in the project and kept moving step after step. At the end of the research, the perceptions of the participating teachers were beginning to change. For example, one of the participating teachers asserted that there was a gradual development of interest in the Productive Pedagogies framework as they progressed.

Similarly, some of the participating teachers felt they will continue with the Productive Pedagogies framework in their further study. These comments came at the end of Phase 1 and during Phase 2.

> *Sir, we had discussed with Jerry that we shall proceed for our masters as soon as we graduated and we will continue to explore Productive Pedagogies because it had help us see mathematics teaching in a different dimension. (Jackson: Research Journal: 2011)*

5.2.2: Reflection on the Benefits of the Productive Pedagogies Framework

In this section the researcher discusses the reflection of the participating teachers on their teaching and how it was achieved when the Productive Pedagogies framework was introduced. In this section, the following themes are discussed. First, the participating teachers observed improvement in students' attitude and interest towards teaching and learning mathematics. Second, the teachers also observed that, the students developed some confidence and trust in their mathematics teachers which gave them courage to overcome the general mathematics phobia. Third, the participating teachers also observed positive improvements in relationships between the teachers and their students, and between students.

Improvements in Students' Attitude and Interest: Students' attitude to mathematics and mathematics teachers in Nigerian classrooms has generated debates among mathematics educators, researchers, teachers of mathematics and educational planners. Different views on the causes and remedy for these negative attitudes of students to mathematics in Nigerian mathematics classrooms had not yielded much or significant improvement. Data collected in this research demonstrated promising improvements in students' attitudes to mathematics when the Productive Pedagogies framework was adopted. The participating teachers reflected that there were appreciable improvements in students' attitude when Productive Pedagogies framework was introduced. For example,

> *The students were serious and committed to their learning. From what the teachers said, they were always ready to defend the solution to their problems as against the background of fear and timidity that greeted most of their classrooms in the past. (Jennie: Research Journal; 2011)*

The participating teachers were of the view that the result of their students being responsible for their learning makes them develop positive attitudes, because they (participating teachers) handed over some of the classroom teaching roles to their students. Jennie asserted that,

> *There were attitudinal changes towards mathematics teaching from the side of the students and towards learning. This is because of the changes in mathematics teachers domineering attitude towards the students. (Jennie: Reflection Meeting 1: 2011)*

She continued,

> *There were also attitudinal changes towards mathematics as a subject, because a girl said that students now love mathematics in the class, and don't look at mathematics as that difficult again. (Jennie: Reflection Meeting 1: 2011)*

Similarly, the participating teachers reflected that there were positive improvements in students' interest to mathematics and mathematics teachers. Jimmy commented,

> *The students were very interested in the way I use Productive Pedagogies to set my class. They were so free to communicate with me…, also…, there were four mathematics teachers using the Productive Pedagogies framework in one classroom…, the students were interested in the way the teachers were coming one after the other, they were always expecting something new from us…, that makes the mathematics classroom activities lively. (Jimmy: Reflection Meeting 2: 2011)*

The participating teachers were of the view that the new framework brought about improvement in their pedagogies which helped to capture the minds and interests of their students. Jackson said,

> *I discovered that using the Productive Pedagogies framework in my class seems to capture the minds and interests of the students. (Jackson: Reflection Meeting 1: 2011)*

In cycle 2 Jerry reflected that,

> *Mathematics teachers and students generally believe that mathematics is best taught in the morning hours in primary and secondary schools. But I observed that using the Productive Pedagogies, mathematics could be taught at any time of the day, whether morning or afternoon. I think the reasons were because we tried to arouse the interest of the students and make learning livelier. (Jerry: Reflection Meeting 2: 2011)*

Improvements in Students Confidence and Trust: Apart from the improvement in students' attitude and interests in mathematics and mathematics instruction, the participation teachers also reflected that there were improvements in students' confidence and trust toward mathematics and mathematics teachers. According to the participating teachers, the introduction of the framework made students develop more confidence during their mathematics classroom instruction. Similarly, the participating teachers reflected that the general phobia that had bedevilled most students towards mathematics in Nigerian classrooms was much reduced. This is as the result of the new confidence observed in students during the classroom instruction of the participating teachers as they employed Productive Pedagogies principles and strategies during their classroom instruction.

> *Productive Pedagogies removes this general fear that students have of their mathematics teachers…, In the situation where the students sit quietly in the class, no talking, their responsibility is just to listen and obey whatever the teacher said does not really give them the opportunity to relate well with the mathematics teacher. (Jennie: Reflection Meeting 2: 2011)*

One other major observation that the participating teachers made from the improvement in their students was the ability of the students to take responsibility for their learning. The classroom activities were student-directed. The culture of the traditional teacher-centred learning gave way to more students-centred learning as the teachers were willing to surrender more of their roles to the students. The participating teachers reflected that they played more of a passive role of supervision and assistance rather than the normal and the traditional role of teaching and dishing out of instructions or information to their students. Jennie commented

> *It seems to me like…, the students to some extent have some control over the learning activities in their various groups…, the teacher only supervises and offers assistance when he discovered students are in sort of a problem…, apart from some levels of control they have on their learning activities, they seems to assimilate faster, when I used the Productive Pedagogies framework in my class. (Jennie: Reflection Meeting 2: 2011)*

Students took more control of their groups and they developed their strategies to find solutions to their problems. The benefit of this approach according to Jennie was that they were not only responsible for their learning but it rather makes them take initiatives and it helps them to learn faster.

Improvements in Relationships**:** Data collected suggested that the participating teachers observed improvement in teacher-student and student-student relationships. This improvement according to the participating teachers was demonstrated through the interactivity that existed between students during their classroom teaching. Students were seeing collaborating and sharing ideas together; the teaching-learning became collaborative rather than competitive.

> *I observed that student-student relationships greatly improved, as one can really see the students interacting with one another and sharing ideas among themselves. It's like they see learning as being collaborative rather than it being competitive. (Jennie: Reflection Meeting 2: 2011)*

In Jackson's initial practice, he did not usually allow students to interact in his class; he viewed that as a distraction and disturbance. However, when he used the Productive Pedagogies framework to set up his class, he reflected that his class naturally became interactive, and he wondered how the change was so dramatic. He noted that this strict and domineering mathematics classroom became relaxed and students began to interact with one another, his students were free to move from one place to the other to seek and give assistance from/to their classmates.

> *My classroom used to be like a graveyard as students dare not talk, but to my amazement when I introduced the Productive Pedagogies framework in my class, the class naturally became interactive, the students interacted in their groups, and before you knew, the solution to the problem was gotten and even those who feared mathematics you see them ready to defend their answers. (Jackson: Reflection Meeting 2: 2011)*

He went further to say,

> *My classroom environment was truly relaxed; hence I created a friendly atmosphere for teacher-student and student-student interactions. Students were moving from one seat to another to ask questions and seek assistance from one another. (Jackson: Reflection Meeting 2: 2011)*

Jennie was also trying to assess her classroom in terms of Recognition of Difference. She reflected that there was effective student participation and involvement during her classroom instruction. Jennie was also of the view that inclusivity was demonstrated in her class, students were involved, and ready to assist and contribute to the mathematics classroom activities.

> *I observed that students' participation was more during in my class, compared to the conventional classroom setting. They felt free and friendly with us, they contributed to mathematics activities in the class and there was interactivity between the teacher and students and between students which was not allowed in the conventional mathematics classroom. (Jennie: Reflection Meeting 2: 2011)*

From the reflection of the participating teachers, this new classroom created good relationships that fostered effective interaction between students. It also helped their students to move freely in the class to seek and give assistance to one another. Jimmy summarises it by saying that

> *The students were so free to communicate with the teachers and also ask them questions. They were also free with their classmates to seek assistance and give assistance where necessary. (Jimmy: Reflection Meeting 2: 2011)*

5.2.3: Reflection on the Unity in Productive Pedagogies Dimensions

The Productive Pedagogies framework is not a teaching method but represents characteristics of good teaching. It is viewed as an effective tool that could be used by mathematics teachers to enhance classroom instruction. The reflection of the participating teachers generally about the framework suggested that there was unity among the 20 elements or the four dimensions of the framework. Actually the four participating teachers had initially picked one dimension each of the framework in the community of practice to conduct their undergraduate projects. However as the research progressed they observed the unity within the 20 elements and or the four dimensions of the framework. They also observed that it was rather difficult implementing one dimension without making reference to some elements of other dimensions. This unity was demonstrated in the comments made by the participating teachers during Phase 1 and 2 of the research. For example, Jennie observed in Phase 1 that:

> *I discovered that all the elements of Productive Pedagogies work together, you cannot really be effective in your own dimension without borrowing from the other dimensions. Just like what the students said that I borrowed from the other people a dimension to make mine better…; I think it's true; because they are like unique and together. (Jennie: Reflection Meeting 2: 2011)*

Similar observations were made in Phase 2 of the research; the participating teachers reflected that mathematics teachers needed substantive conversation and students' engagement if high Intellectual Quality problems are to be solved in the class. Some of them said,

> *I will also want to say that from experience on this Productive Pedagogies framework some elements need others to be implemented or manifested. For example a teacher needs a lot of student engagement to achieve substantive conversation; you also need a lot of substantive conversation to achieve higher order thinking, deep understanding and knowledge as problematic*

> *especially when highly Intellectual Quality problems are given. (Jackson: Casual Interview, 2013)*
>
> *Students need a lot of substantive conversation to solve highly Intellectual Quality problems that required higher order thinking, deep understanding and knowledge as problematic especially when highly Intellectual Quality problems are given. (Jerry: Casual Interview, 2013)*

In view of this, the participating teachers used elements of other dimensions to improve their teaching. This suggests that they were not restricted to the elements of their own dimensions selected at the beginning of the research. The following observations were made by the researcher to support the reflection of the participating teachers on the unity among the dimensions of the Productive Pedagogies framework. First, the researcher observed in Jennie's classroom teaching, in Phase 1 that Jennie was using Recognition of Difference to achieve quality classroom:

> *I stood at the window in cycle 2 implementation classes and watched when Jennie introduced simultaneous equations to her students; she decided to use the students to mention things people do at the same time. In the process the students were able to mention some things that happen together, they were able to say singing and dancing go together, eating and drinking go together and some other examples. In this way she was able to achieve the cultural knowledge and inclusivity as well as achieving students' engagement. (Research Journal: 2011)*

From the observation above, Jennie intended achieving inclusivity and cultural knowledge in her class. In trying to achieve that she also wanted every member of the class involved in the classroom activities which could be described as students' engagement. However, in her effort to achieve these elements she was also able to achieve Connectedness. This is because she used the concept of singing and dancing and eating and drinking which are real life happenings in the society to described simultaneous equations as involving two equations which though different meet at a point. Similar observations were made by Jackson during a reflection meeting on the activity above.

> *She asked the students to mention two things that happen together at the same time…, some students said; singing and dancing happen together, others said; eating food and drinking water and many other beautiful examples students brought out in the class. She then immediately connected the word "together or concurrently" to mean simultaneous and make the students to understand the meaning of simultaneous equations, that is connectedness to the world. (Jackson: Reflection Meeting: 2011)*

Secondly, Jackson was trying to achieve students' engagements in a Supportive Classroom Environment during his classroom teaching when he was deriving the quadratic formula with the students. From the researcher's observation of Jackson's classroom teaching, he was trying to implement students' engagement; however, the researcher observed that knowledge integration and background knowledge of Connectedness were also achieved.

> *I observed that Jackson at each stage of the lesson asked the students to demonstrate what they knew about completing the square method and linked it to the development of quadratic formula. At any stage he also discovered that when his students confused he would go back to the completing the square method again and follow the same principles of asking the students to refresh their minds on what they had learnt about the previous method. From the observation of this approach it revealed that Jackson effectively engaged his students in the classroom activities which made Jackson's classroom teaching participative. (Research Journal, 2011)*

From this observation the researcher discovered that Jackson achieved students' engagement and also knowledge integration, and background knowledge. Jerry reflected:

> *From my observation of the development of the quadratic equation there was full participation of students in the lesson; the students were working together as against what happened in cycle 1. (Jerry: Reflection Meeting 2: 2011)*

Jennie supported this assertion by saying:

> *I observed there was active involvement of students in Jackson's classroom teaching and at times you will see the students leading the lesson in the class which means that he gave them free hand to direct the class. (Jennie: Reflection Meeting 2: 2011)*

5.2.4: Summary

In this second section of the study, the researcher analysed the data that was aimed at answering research aim 2 as stated in Section 5.0. The research aim was based on the reflections that the participating teachers had done on their practice which was analysed in Section 5.2. First, the analysis revealed that the participating teachers approached the framework with some initial scepticism which as the research progressed they overcame and became more interested in the framework.

Secondly, the analysis in Section 5.2.2 revealed that the participating teachers reflected on some benefits they obtained in their effort to use the Productive Pedagogies framework to improve their practice. These identified benefits were improvement in their students' attitudes and interests to mathematics, improvement in their students' confidence and trust not only in them as teachers but also in the teaching and learning of mathematics as against the traditional classrooms. The study also revealed improvement in student-teacher relationships. Finally, the analysis suggested that the elements of Productive Pedagogies are interrelated. This is because the four participating teachers each picked one dimension of Productive Pedagogies in a community of practice and the analysis of their practice revealed that they found it difficult dwelling on their dimensions without making reference or application to elements of other dimensions.

5.3: Challenges Encountered

In the analysis in Chapters 4 and 5 the researcher looked at the participating teachers' initial practice and the fact that there were improvements in their teaching. The researcher had also considered the views of the teachers on how they relinquished some of their powers to their students and the resultant effect on their classrooms instruction. It had also been observed that the tense mathematics classroom that looked unfriendly between mathematics teachers and their students became relaxed, and or the "the graveyard-liked" (meaning silence classroom) mathematics classrooms of the domineering teachers also crumbled and gave way to a relaxed, friendly and interactive mathematics classroom climate.

Improvements and benefits were identified and reflected upon by the participating teachers on the effectiveness of the Productive Pedagogies framework in their mathematics classroom teaching. There were certain challenges that were observed to have confronted the effective implementation of the Productive Pedagogies framework during the research which had been discussed in Chapter 5. In this chapter the researcher will focus on the analysis of the contextual challenges that confronted the effective implementation of the framework. This constitutes the last research aim of the study which states "To investigate the challenges encountered by the participating teachers while introducing Productive Pedagogies to the Nigerian mathematics classroom".

These challenges were termed contextual challenges confronting the participating teachers' effectiveness in their effort to achieved quality classroom instruction using the Productive Pedagogies framework. From the information collected during the reflection meetings and my observations of the classroom teaching of the participating teachers, certain difficulties were encountered by the participating teachers in the class. The rationale behind discussing these contextual challenges in the context of this research suggests that the researcher and the participating teachers did not only reflect on the benefits and changes observed in the participating teachers classroom teaching using the Productive Pedagogies framework, the researcher and the participating teachers also identified some challenges that attempted to affect the entire research project.

One of the major contextual challenges that confronted the effectiveness of the participating teachers during the research project was the time allocated to the teaching of mathematics in the school time table. There was the general cry from both the participating teachers and the focus group students in Phase 1 of the research that the compulsory 40 minutes mathematics period in Nigerian schools was not enough for effective implementation of Productive Pedagogies. They were all of the view that for effective teacher-student and student-student conversations, more time is required for teachers to effectively engage their students in effective classroom interaction or conversation. Jackson argued,

> *There is the problem of time generally; time management was not easy for us, because with this Productive Pedagogies model, honestly to effectively implement it 40 minutes is not enough for it.* (*Jackson: Reflection Meeting* 2: *2011)*

In supporting the view of Jackson Jerry asserted that,

> *I think Jackson is right sir, this need time if the beauty of this model of classroom practice is to be clearly seen and appreciated. I think is best for double periods not just this 40 minutes single period. (Jerry: Reflection Meeting 2: 2011)*

However this challenge was overcome during Phase 2 of the research. The participating teachers were given a double period of 80 minutes for their classroom instruction and from the researcher's observations of the classroom teaching of the participating teachers, the teachers had enough time to demonstrate the various activities they wanted their students to exhibit and there was enough time for the student-student interactions and teacher-student interaction they clamoured for in Phase 1.

Perhaps one other important challenge observed in this research is the limited time the researcher had to introduce the Productive Pedagogies framework to the participating teachers. The Productive Pedagogies framework was a new principle to the Nigerian mathematics classroom. Participating teachers could have had fewer challenges implementing the framework if this concept had been part of their study unit in the university. Two days of workshop participation and the scaffolding may not have provided enough information for the participating teachers to effectively implement the framework to achieve quality classroom instruction.

Similarly, the researcher wishes to also note that change in practice on many dimensions is not easily achieved in a limited time. The participating teachers needed more time to study the concept before implementing in the classroom. This was, however, not the case for the participating teachers in this research. The concept was introduced to them over the weekend and by Monday the following week they were in the class to implement what they had learnt. The difference was however observed in the Phase 2 of the research. The researcher observed that the participating teachers were more effective in their implementation in Phase 2 than in Phase 1.

Another challenge identified by the participating teachers affecting their classroom practice during Phase 1 of their implementation was the challenge of classroom space. They were of the view that effective implementation of the Productive

Pedagogies framework requires space for students to freely move around to interact within and outside their groups. However, they did not have that opportunity to move around because the classroom that was meant to accommodate 20 students was allocated to 43 Senior Secondary School 2 students.

According to the participating teachers, this affected the free movement of the students and challenged the effectiveness of student-student and teacher-student interactions, especially when it involved what was regarded in the research as the intergroup interaction. This is the situation where students seek assistance from their colleagues in a group outside theirs. Jackson summarises this assertion by saying that:

> *There was no enough space for free movement in the classroom during my classroom practice. This affected the teacher-student and student-student interactions in the classroom. (Jackson: Reflection Meeting 1: 2011)*

From the observations in Phase 2, it was found that the participating teachers overcame this problem of space availability. The teachers were allocated classrooms with larger spaces and fewer students. Therefore the challenges were overcome as the students had enough space for free movement around the class during their classroom interactions and support.

Summary: In conclusion, this section of the research considered the third and last research aim stated in Section 5.0. This aims looked at the contextual challenges the participating teachers faced while implementing Productive Pedagogies framework as stated in Section 5.3. The analysis above suggested that the participating teachers did not accept the concept of Productive Pedagogies without some criticisms especially in the Nigerian context.

Similarly, the analysis also suggested some contextual factors that confronted the implementation of Productive Pedagogies. Some of these factors were identified as the time allocated to the teaching of mathematics in the school time table and classroom space for effective group and intergroup interactions among the students. However from the findings of the research some of these factors were overcome in Phase 2 of the research as the researcher made effort to look into the possibility of having double periods for each of the participating teachers in Phase 2 and larger classroom spaces.

5.4: Summary

This chapter discusses three research aims. The first aim concentrated on the changes observed as a result of the participating teachers' implementation of the Productive Pedagogies framework. The researcher observed that the participating teachers adopted the problem solving strategy as a means to achieving and encouraging solving highly Intellectual Quality problems by their students. The analysis also showed that, when students were given highly Intellectual Quality problems, collaboration and substantive conversations were usually re-enforced among the students. Similarly, the analysis in this section revealed that the participating teachers and their students made used of some improvised materials to achieved Connectedness. This helped make the participating teachers' mathematics classroom instruction real and practical to the students. Still on Connectedness, it was revealed that the participating teachers explored their students' background knowledge to make their mathematics instruction real and practical.

The analysis in Section 5.1 also demonstrated that an atmosphere of friendship and support was provided to the students. This kind of atmosphere helped in building students' confidence in approaching their teachers in solving highly Intellectual Quality problems. It also created in students the sense of belonging and responsibility not only to their learning but to the members of the classroom community. Finally, from the analysis, the study revealed that the participating teachers were able make use of the cultural practices of the different multicultural groups found in their classrooms in their teaching, especially in Nigeria with over 350 tribes. Differences of culture, religion and socio-economic status were well managed by the teachers.

However, the findings of the study in this section also suggested that the participating teachers experienced several limitations in implementing some elements of Productive Pedagogies. These limitations included providing students with lower order thinking materials, the inability to link the real life classroom instruction with the content being taught, and finally difficulties in implementing connectedness to the world when teaching abstract mathematics topics.

In Section 5.2 of the study, the researcher analysed the data that was related to answering research aim 2. The research aim was based on the reflections that the participating teachers had on their practice. The analysis revealed that the participating teachers approached the framework with some initial scepticism which as the research progressed they were able to overcome and became more interested in the framework. Hence they reflected on the benefits of using the Productive Pedagogies framework in reforming their classroom practice. The benefits that the participating teachers reflected on includes; improvement in students' attitudes and interests towards mathematics, improvement in students' confidence and trust not only in them as teachers but also in the teaching and learning of mathematics as against the traditional classrooms and improvement in student-teacher relationships.

Finally Section 5.3 of the research aims looked at the contextual challenges the participating teachers faced while implementing the Productive Pedagogies framework. These included; the inability of the participating teachers to acknowledge the concept of Productive Pedagogies. They approached the framework with some criticisms especially in the Nigerian context. The analysis also suggested several contextual factors that impeded the implementation of the Productive Pedagogies framework. Some of these factors were identified to be time allocated to the teaching of mathematics in the school time table and classroom space for effective group and intergroup interactions among the students. However from the findings of the research some of these factors were overcome in Phase 2 as discussed in Section 5.3.

CHAPTER 6

DATA ANALYSIS 3: STUDENTS' PERCEPTIONS

6.0: Introduction

In Chapter 4, the researcher discussed the scaffolding given to the participating teachers to help them provide a classroom that will help them achieve quality classroom teaching. Similarly, in Chapter 5 the researcher discussed the implementation, reflection and some challenges the participating teachers faced implementing the Productive Pedagogies framework. In this chapter the researcher discusses the perceptions of the students on their engagement using Productive Pedagogies framework. The chapter seeks to answer the research aim stated in Chapter 1 that says '*to investigate the perceptions of students on the effects of Productive Pedagogies framework on their engagement'*. The major source of data in this chapter is the focus group discussions held with six students.

In this chapter the researcher analysed the data on the perceptions of students about their engagement using the following themes. First, the students discuss the benefit they obtained from collaboration within the classroom. Second, the students discuss their views on how they were engaged in problem solving as evidence of engagement during the participating teachers' classroom instruction. Third, the students were of the view that there was quality student-student and student-teacher interaction. Fourth, there were also improved student-student and student-teacher relationships as observed by the focus group students. Fifth, this section discusses the atmosphere of support that prevailed during the classroom instruction as observed by the focus group students. Sixth, the resulting inclusive classroom created by the participating teachers is discussed.

6.1: Students' Views on Collaboration within the Classroom

Students' earlier perceptions of their mathematics classroom engagement had been that of passive involvement. The teacher does the teaching and all the talking, while the students do the listening and only respond when they are asked. This does not makes mathematics classroom instruction interesting and hence make students dislike mathematics and indeed also the mathematics teachers. Other problems that make students dislike mathematics include the unfriendly atmosphere created by most mathematics teachers and the mathematics teachers' teacher-centred traditional classroom instructional approach. According to the students some teachers can go as far as sending students out of the class if they discover such students are trying to share ideas with one another during classroom teaching. Janet argued,

> *You sometimes find it difficult to understand what the mathematics teacher is saying and you dare not talk. But now the teachers are friendly and you also have your classmates to interact with in areas you don't understand. (Janet; Focus Group 3: 2011)*

Another student supported what Janet said:

> *That is true Janet, sometimes some teachers will even send you out of their class if you asked questions, and I wonder how this change was so natural and dramatic. (Julie: Focus Group 3: 2011)*

However, from the views of the focus group students, there was a dramatic change in classroom practice when the participating teachers changed their approach to classroom teaching using the Productive Pedagogies. The teachers used group teaching strategies during their instruction and the students appreciated the approach. They were of the view that these grouping strategies encouraged collaboration among students. They were able to think collaboratively, share ideas together, and participate in classroom activities. This section discusses the perceptions of the students on how they benefited from this collaboration.

First, the focus group students were of the view that there was collaboration of ideas among them. When the teacher gives them a problem to be solved, you see the students collaborating together, sharing ideas among themselves on how to come up with the desired solution to the problem. The students liked it and were happy working collaboratively, suggesting the benefit of collaboration during classroom instruction. Julie supported this by saying,

> *All the group members solve the problems together, you bring your own idea…, I bring my own idea… we join it together… and solve the problem. I think that is good. (Julie: Focus Group 3: 2011)*

Second, it was not only the collaboration of ideas that makes classroom engagement interesting for the students; the focus group students were of the view that the students also enjoyed thinking together, sharing their thoughts on how to come up with the solution to their mathematics classroom problem. The students were of the view that collaborative thinking is a better way to solve difficult mathematics problems. Julie said,

> *This is not only you alone thinking on how to solve a particular problem, the thinking is in a group, by the time we join our heads together and think on a solution to a particular mathematics problem, you bring your idea… I bring my idea…, the solution becomes easier. (Julie: Focus Group 3: 2011)*

Another student was of the view that,

> *When the teacher was teaching, he gave us a question to solve, and that question was "firebulous" (meaning too tough), we had to think…; think…; and think…; in our groups before we were able to come up with the clue of what to do. (Mike: Focus Group 3: 2011*)

Third, another benefit of collaboration identified by the focus group students was the active participation of students in the classroom activities. According to the students, instead of them being mere passive recipients of knowledge, they were actively engaged in creating and constructing their knowledge through active participation which made them contributors of knowledge. They were doing most of the work in the class with their teachers playing passive roles of assistance in areas of difficulties. This active participation of students and their contributions to knowledge made them learn faster and better. Jane was of the view that,

> *There was good classroom participation… every member of the class participated…, the teacher always asked students to solve problems on the board instead of him doing (solving) it for them, the students were doing most of the work and he (only) assisted when he discovered that the students are hook-up (difficult to continue). I think these approaches aid students' understanding better than when the teacher is doing all the work. (Jane: Focus Group 2: 2011)*

Also from the data collected, another benefit of student collaboration was that the students had the opportunity to work in groups. From the view of the focus group, working in groups kept students busy and aided their mathematics classroom engagement. One of the students observed,

> *Whenever there is a problem to be solved, the teacher will first ask them to discuss the problem, and then solve it within the group, and finally gives each group the opportunity to defend their solution before the members of the class. (Research Journal: 2011)*

Similarly, the focus group students were also of the view that this makes them work together, share ideas among themselves and take responsibility for their learning. Michael supported this by saying,

> *The teacher writes the question on the board and asks us to solve it in groups first, before going to the board to solve it for the class, that is, to some extent he allow the student to try the problem first before he solves it for them on the board. (Michael: Focus Group 3: 2011)*

Jane supported the perception of Michael by looking at the benefits of cooperative groups to the low achievers. She was of the view that the low achievers were encouraged and were carried along as the students were collaborating during the classroom instruction. This makes classroom instruction all inclusive.

> *The seating positions created by the mathematics teachers' tends to encourage slow learners. We were fixed to sit in groups like in a circular form, and we were made to interact with one another in the class, that encouraged the slow learners and they were not left out…, they were carried along. It also made us so engaged; we debated and defended our solutions… and everybody was contributing his or her ideas in the class. (Jane: Focus Group 3: 2011)*

The findings of the study also suggested that it was not only the slow learners that benefitted from these collaborative groups, other students also benefitted from the grouping system. For example, the high achieving students were observed to have taken responsibility for guiding learning in their groups. Groups also had the opportunity to debate and defend their results before other groups and the whole class. This helped the students to work together to achieve a common goal; they were able to cooperate with one another, showing support to one another. This observation suggests that for any effective classroom engagement, the students do not only need collaborative thinking and sharing of ideas to succeed, they also need one another's cooperation. This point also suggests that this cooperative effort affords the mathematics teacher the opportunity to go round the class and offer assistance and support to students with special needs. Julie supported this by asserting that,

> *During the classroom teaching, I saw how the students were working together and the teacher was moving from group to group to offer support to weaker groups…; it was just good. (Julie: Focus Group 2: 2011)*

6.2: Students' Views on their Engagement in Problem Solving

From the perceptions of the focus group students, the teaching strategy adopted by the teachers encourages their engagement in problem solving. Generally, in most mathematics classrooms in Nigeria, problem solving is viewed as something challenging to most students, perhaps because most mathematics classrooms instruction in Nigeria is teacher-centred where students are not given the opportunity to contribute to classroom instruction. Similarly, perhaps some teachers also have problems in engaging their students in problem solving due to their lack of appropriate pedagogical knowledge or use of strategies to adopt to encourage problem solving among students.

This was one of the challenges identified during the workshop which could be described as factors affecting effective students' engagement in mathematics. From the views of the students during focus group discussions in Phase 1, positive changes in their teachers were observed during the classroom instruction. Students were of the view that their mathematics teachers were good; they engaged them in productive problem solving. They were kept busy. This suggests that when mathematics teachers give students the opportunity to solve problems on their own it usually keeps them away from distractions and keeps them busy on productive problem solving during classroom instruction. Micah said,

> *The teachers were good, because we were fully engaged in solving problems in the class. They gave class work and assignments which really kept the students busy (engaged). (Micah: Focus Group: 2011)*

This also suggests that problem solving encouraged collaboration among students by helping them share ideas in their efforts to solve problems given to them during classroom instruction. For example the focus group students asserted that, *There was a problem given to us on quadratic equations which was difficult. As a result of collaboration we were able to find solution to the problem. (Michael, Focus Group 3: 2011)*

That is true, when the teacher gave us that question to solve…, the question was "firebulous" (meaning too tough), we had to think…, think…; and think…; in our groups before we were able to come up with the clue of what to do. (Mike: Focus Group 3: 2011)

This point suggests that difficult problems are solved through collaboration of thoughts and ideas during classroom instruction when mathematics teachers encouraged sharing of ideas among students.

The question given was somehow difficult to solve, and the teacher allowed interaction within the groups…; everybody put his or her head together and the solution was at last obtained and the problem was eventually solved. (Janet: Focus Group 2: 2011)

Another aspect of problem solving that made the students enjoy their mathematics classroom engagement was the fact that the teachers gave them opportunity to be responsible for their own learning. These activities suggest that when mathematics teachers make students responsible for their own learning, it tends to make them work harder. Julie was of the view that this is the better way of learning. This suggest that when teachers give students a task and allow them face it independently, it makes them accountable and motivates them to work harder and to take risks in their learning as promoted in the Productive Pedagogies framework. Julie was of the view that,

The teacher really tried…, he…, like…, made sure everybody is carried along and should be able to solve problems in the class. And he made it clear to us that everybody most make sure he understands and be prepared to solve the problem…, because he can call anybody in the group…, on the groups we see to it that I bring my own idea, you bring your own idea and we put our ideas together. (Julie: Focus Group 1: 2011)

This comment of Julie suggested that comments made by teachers motivate students to problem solve. Jane supported the view of Julie and suggested that the comments of one of the participating teachers served as a motivation to them to make sure that every member of their group was able to solve the problem. She observed these motivational comments encouraged collaborative problem solving among students. She said,

> *In fact when he said he can call anybody to solve the problem: it makes everybody sit up and make sure he understands because you don't know if you are going to be called to solve the problem on behalf of your group. (Jane: Focus Group 1: 2011)*

Another observation made by the focus group students suggested that it is not just being able to know how to solve mathematics problems provided by their teachers that is important, but also having the ability to defend your solution. Jane also identified the benefit of the teachers' motivation to include students' involvement in classroom activities. The social justice of debating and defending the solution to their mathematics problems is one of the things that they enjoyed during the problem solving. Jane said,

> *That helps all of us to be fully engaged; we debated and defended our solutions… and everybody was contributing his ideas in the class. (Jane: Focus Group 1: 2011)*

6.3: Students' Views on the Quality of Interaction in their Classroom

Mathematics engagement among students cannot be effective and efficient if there are no student-teacher, teacher-student and student-student interactions. The grouping system will also end up being the usual teacher-centred learning if the students are not allowed to interact with one another. Effective problem solving and collaboration among students as discussed above can only be possible if the mathematics teachers make their classroom instruction interactive. Such interaction is also important if the mathematics teachers intend to achieve effective engagement among students.

The initial fear at the beginning of the research was that the students may use the interactivity situation to distract one another, as discussed in Chapter 5. However, when the research started, it was found that the students were engaged in classroom discussion, which did not give them the opportunity to be unnecessarily distracted. The secret behind this was revealed in the perceptions of focus group students who asserted that the mathematics teachers engaged them in productive interaction which gave them no room for any form of distraction. This section will look at the perceptions of the students on the types of interactions the nature of interactions and the effects of interactions during mathematics classroom engagement.

6.3.1: Types of Interactions

Looking at the types of classroom interaction that existed during the mathematics classroom practice, the data collected demonstrated that the focus group students enjoyed some forms of interaction during their classroom instruction. Four different types of classroom interaction were observed and enjoyed by the students. This includes; first, the interactions that existed between the teacher and the chalk board which they called *teacher-chalk* interaction. Second, the interaction between teacher and his student called *teacher-student* interaction. Third, the interaction that existed between students and teacher called student-teacher interaction. And finally, the focus group students identified the interaction that exists between students called *student-student* interactions. However from the view of the students, the types of interaction are generally determined by the person that initiated the talk during classroom instruction.

***Teacher-Chalk Interaction*:** The first type of classroom interaction the focus group students identified was the teacher-chalk interaction; this was defined by the students to mean the type of interaction where the teacher will be talking and facing the board instead of facing the students. The students frowned at this type of interaction and were of the view that it should not be encouraged during classroom instruction. The focus group students were also of the view that they did not enjoy this form of interaction as it only helped promote the traditional classroom instruction which they believed tended to be the teacher-centred.

Similarly, the focus group students were of the view that teachers adopting this form of interaction make their classroom boring and ineffective because teachers do almost all the talking and there is no room for students to contribute to the conversation. Information from the students revealed that the initial mathematics classroom practice of the teachers in cycle 1 were basically teacher-chalk interaction. However, as the study progressed the teacher-chalk interaction was gradually replaced with the other types of classroom interaction. Some of the comments made by the students on this form of interaction include:

> *The teacher was just talking to the board (Mike: Focus Group 1: 2011).*
>
> *The teacher classroom interaction was just teacher-chalk interaction (Julie: Focus Group 1: 2011).*
>
> *The interaction was just between the teacher and the chalkboard called teacher-chalk interaction. (Micah) (Focus Group 1: 2011)*

***Teacher-Student Interactions*:** The second type of interaction identified by the students during the classroom teaching is what they called teacher-student interaction; this is the type of interaction that exists between the teacher and the students. In this type of interaction the teacher does more of the talking. However, the focus group students were of the view that substantial responses are required from the student because even though the teacher talked more in this type of interaction students also made a substantial contribution to the discussion. The focus group students were of the view that this is a better form of interaction compared to the teacher-chalk interaction. This is because in this form of interaction the teacher pauses at some intervals to allow students contributions.

> *To me, there was a good teacher-student conversation…, the teacher did his best in maintaining this conversation in the class, which I believe leads to deep understanding among the students. This makes his cycle 3better than cycle 2 and 1. (Jane: Focus Group 3: 2011)*

The students were also of the view that this type of interaction is sometimes observed during question and answer teaching techniques. The teacher asked the students questions and the students responded to the teachers' question. Michael supported this by saying,

> *When the teacher was teaching he was asking students questions…, the students were responding and answering…, I think that is classroom interaction between teacher and student. (Michael: Focus Group 3: 2011)*

***Student-Teacher Interaction*:** Perhaps, one may think that this type of interaction is the same as teacher-student interaction. However the focus group students viewed them differently. They were of the view that this form of interaction involves student initiated discussions with their teachers. This could be in the form of students asking their teachers questions to seek further clarification or a student defending his or her views in a debate between the teacher and the students in the class.

This is among the higher levels of interaction, where students to some extent do more of the talking i.e., the students participate actively in classroom interactions and teachers'- only respond to the students to add comments or to move them to further talk. This was seen in what Michael said, that the students were asking the teacher questions which according to him qualified as student-teacher interactions.

> *When the teacher was teaching we were asking him questions on what we did not understand and he was answering us, so, I think that is classroom interaction between student and teacher. (Michael: Focus Group 3: 2011)*

This kind of interaction could also take the form of students discussing one-on-one with the mathematics teacher trying to clarify their claims and position on particular classroom problems. This could be observed when a student attempted to explain a particular view to the teacher through dialogue or debate or by trying to defend a point or an opinion on a topic under consideration.

> *We debated and defended our solutions… and everybody was contributing his ideas in the class. (Jane: Focus Group 1: 2011)*

This suggests that when student-teacher interaction is encouraged during mathematics classroom instruction students understanding increases. Janet supported this by saying,

> *There was student-teacher interaction within the class. I think this leads to what I call deep understanding…, the way the students were asking him questions shows that there was deep understanding among students. (Janet: Focus Group 3: 2011)*

Student-Student Interactions: The final type of interaction that existed in this classroom is what the students called student-student interactions. The focus group students said that, even though they enjoyed and appreciated the beauty of teacher-student and student-teacher interactions. They suggested that student-student interactions are preferred to all other forms of interactions created by the participating teachers.

According to the focus group students, student-student interactions should be viewed a better form of classroom interaction that should be encouraged during mathematics instruction. It was also a new form of mathematics classroom interaction they were experiencing during mathematics classroom practice. The focus group students were of the view that most mathematics classroom instructions they had experienced before had been in the traditional classroom where they are made to sit quietly in the class and listen to their teachers dish out instructions. However encouraging student-student interactions provided opportunities for students to contribute to classroom instruction and they had the opportunity to present their thoughts to the class. Janet commented,

> *Before…, you sometimes find it difficult to understand what the mathematics teacher is saying and you dare not talk. But this time around…, you have your classmates to interact with in areas you don't understand. (Janet: Focus Group 3: 2011)*

The student-student interactions are that form of classroom interaction that is initiated between students; however, teachers could also initiate it and help sustain it during classroom instruction. This approach suggests that for any effective mathematics classroom instruction student-student interactions are very important and makes mathematics classroom teaching and learning more student-centred. The focus group students were of the view that it makes students interact with one another and work together to find solutions to their common mathematics problems. It makes high achieving students in the class offer some assistance to the low achieving students and thereby encourages a student-centred approach to classroom instruction.

The data also suggested that student-student interaction devolves responsibility to the students, as in their groups they have a responsibility to make sure that every member of the group participates in the classroom activities. Janet was of the view that,

> *When we were solving problems, there was always student-student interaction in our group…, this student-student interaction… I think leads to what I call deep understanding…, the way the students were responding to the teachers' questions shows that there was deep understanding among students. (Janet: Focus Group 3: 2011)*

Another student also said,

> *There was student-student interaction or conversation whatever you want to call it…, we interacted in our group…, some students from other groups came to our group to seek assistance …, and we assisted them on the problem given to us. (Julie: Focus Group 3: 2011)*

6.3.2: Nature of Interactions

Apart from the types of interaction that existed between students and the participating teachers during mathematics classroom teaching, data collected in this research suggested that the interaction during mathematics classroom teaching takes two formats. The students were of the view that there is what they called *whole class interaction* and *group interaction*.

***Whole Class Interaction*:** According to the focus group students, the whole class interaction is that form of interaction that is directed by the mathematics teacher. It is mostly done during teacher-student interaction. The students appreciated this form of interaction and commented that it brings about cordial relationships between the teacher and the students and it encourages effective discussion during classroom teaching. Mike supported this by saying,

> *The mathematics teacher was able to bring the students together and it was like there was good interaction between the teacher and the students. (Mike: Focus Group 1: 2011)*

Group Interaction: According to the focus group students, even though the students enjoyed the whole class interaction and that it brings all the class together during classroom instruction. They preferred the group interactions and suggested that they should be encouraged during classroom instruction. They were of the view that group interactions break the class into smaller units and students interact in these smaller units where ideas are shared and individualized needs are commonly and easily identified within the group and met without the unnecessary interference of the teacher. From the researcher's interaction with the focus group students, two types of group interactions were identified. For example Micah identified these groups interaction as the *within group interaction* and the *intergroup interaction* and when asked to further define each of these said;

> *Student-student interactions should be within the group and outside the group: - within the group is when students discuss problems within their group, while without the group is when students go to other groups to give or seek assistance to their problem. (Micah: Focus Group 3: 2011)*

Was there evidence of these two interactions within this class? Janet had this to say:

> *There was student-student interaction or conversation - whatever you want to call it…, we interacted in our group…, some students from other groups came to our group to seek assistance …, and we assisted them on the problem given to us. (Julie: Focus Group 3: 2011)*

The Within Group Interaction: The within group interaction is that form of interaction that exists between two or more students, grouped together (or grouped by their teacher) to interact and discuss a particular mathematics problem. This form of interaction was appreciated by the students in the class and they made positive comments about it. What happened was that the mathematics teacher grouped the students together and insisted that problems are to be solved in groups through collaboration and interactions between students before the teacher solved it generally with the whole class.

The effect of this interaction was that it encouraged the slow learners; the high achieving students all worked together to share ideas and help one another understand the problems they were solving during classroom interaction.

> *We were fixed to sit in groups like in a circular form, and we were made to interact with one another in the class; that encouraged the slow learners and they were not left out, they were carried along. (Jane: Focus Group 3: 2011)*

***The Intergroup Interaction*:** The focus group students viewed this as a form of interaction where students from one group seek or give assistance to students from other groups. Janet supported thing by saying,

> *There was students'- interaction within our groups and some students from other groups came to our group to seek assistance and we assisted them on the problem given to us. So the conversation was both within and outside the group. (Janet: Focus Group 3: 2011)*

6.3.3: Benefits of Interaction

The analysis in this section looked at the benefits of good interactions in the classroom. From the views of the focus group students it was suggested that interactive mathematics classrooms make teaching and learning interesting to students. This suggests that when mathematics teachers make their classroom practice interactive, students find their learning more interesting, and this makes them focus on the task and gives no room for classrooms distractions.

> *The mathematics teachers make the mathematics classroom practice very interesting; students were interested and pay close attention to what the teacher was doing in the class. (Mike: Focus Group 3: 2011)*

Evidently, interaction during classroom instructions bring students together, it also adds to mathematics teachers' effectiveness and hence encourages students understanding of the topic.

> *The teachers brought the students together and it was like there was good interaction between teacher-student and student-student. (Mike: Focus Group 3: 2011)*

Another student also commented that group interaction helps students'-gain a deeper understanding.

> *To me there was a good teacher-student conversation…, the teacher did his or her best in maintaining this conversation in the class, which I believe leads to deep understanding among the students. This makes his cycle 3 better than cycle 2 and 1. (Jane: Focus Group 3: 2011)*

6.4: Students' Views on their Relationships with the Teacher

From the analysis in Chapters 4 and 5, extensive discussions had been made on the domineering attitude of mathematics teachers in Nigerian schools and the problems associated with it as described in Chapters 4 and 5. Since Chapter 6 discusses the views of students on their engagement, there could be some repetition of these issues. The students were of the view that this domineering and unfriendly attitude of teachers sometimes made them dislike mathematics and sometimes made them feel that mathematics teachers are unfriendly. This suggests that students' problems in mathematics are not restricted to their negative attitude, but could be as a result of the way mathematics teachers organized their classrooms during instruction. Julie argued:

> *Generally in most mathematics classrooms, teachers are too strict and scared students away from participating in classroom activities…, to my own*

> *understanding mathematics teachers are not supposed to be strict because students are finding it hard today to learn mathematics. (Julie: Focus Group 1: 2011)*

From what Julie said, it suggests that students are finding it hard to learn mathematics in most Nigerian mathematics classrooms because of the mathematics teachers' strict stand on how mathematics should be learnt or taught. The view of Julie also suggests that when mathematics teachers are strict during classroom instruction it sometimes cause mathematics phobia among students. However the students were of the view that, in a situation where mathematics teachers are friendly and approachable, as observed from the participating teachers' classrooms during the research, students' attitude towards mathematics also tends to improve.

> *Sometimes the mood in your face alone makes people to be attracted or run away from you, and if your mood is friendly the students will be willing to listen to you. But when your mood is not friendly and you tight your face, I personally will be scared of you and whatever you are saying, I will not pay attention to you, and I will not enjoy or understand what you are saying as a teacher in the class, because of your strictness as mathematics teacher. (Julie: Focus Group 1: 2011).*

The change in the participating teachers approach to mathematics classroom instruction brought about a reduction of the participating teachers domineering attitude during classroom instruction and students' engagement increased. There was also an improvement in student-teacher relationships. This is also suggesting that when mathematics teachers are friendly and approachable, the students will be attracted to them. The benefit of this is that the students will be able to approach the mathematics teacher for help.

> *This time around the teacher was friendly ... I think we need a free and fair classroom where everybody will have the opportunity to approach the teacher on areas of misunderstanding or difficulties. (Janet: Focus Group 2: 2011)*

Another student also commented by saying:

> *The teacher really improved in his mood and appearance, because in his cycle 1…, his appearance was not welcoming. But this time, he tried his best to respect the class and the class also respected him. He also respected the ideas brought by the students; he was not (like) discarding them. (Jane: Focus Group 3: 2011)*

Another observation from the focus group students suggests that there was improvement in teacher-student relationships. The students were of the view that when a mathematics teacher recognises and respect the views of students, as observed by Jane above, stopped being harsh and unfriendly to students, and created a cordial student-teacher relationship, the classroom climate is usually relaxed and students contribute profitably to the mathematics classroom practice. Julie said;

> *The new classroom framework brings about good and cordial student-teacher relationships; In fact it brings about good student-student relationships. I wonder how this change was so natural and dramatic. (Julie: Focus Group 3: 2011)*

Jane supported the view of Julie by saying,

> *It's like someone is always there… very close to you… to say, O girl? Is there any problem? Do it this way, this way, and this way. The classmates also… the teachers… are always there… willing to assist… willing to show the way. (Jane: Focus Group 3: 2011)*

The data also suggested that where there are cordial and profitable student-teacher relationships during classroom instruction, respect among members of the group improved. Janet said,

> *The concept of recognition… makes all students equal…, teachers are no more harsh and hard on students… there was cordial relationship between teachers and students and everybody was regarded and respected…, a mathematics teacher that is friendly listened to every student, and every student contributes to his classroom practice and had his/her opinion counts. (Janet: Focus Group 1: 2011)*

Finally when there are good student-teacher relationships there will also be the presence of friendship and unity among students. The focus group students were of the view that the classroom climate created by the participating teachers brought about good student-student relationships. From the views of the students, they were united with one another; there was no room for misunderstanding and misrepresentation. There was also cordiality among them during their classroom instruction and after. This suggests that effective student-student relationships create an atmosphere of friendship and unity among students.

> *The classroom environment created by the teachers brings about unity and love among us (students) in the class, which brings about excellent cooperation between students and between teachers and students. (Janet: Focus Group 3: 2011)*

6.5: Students Views on Support that Prevailed in their Classroom

Support is showing concern to someone in need. When someone did not understanding a particular concept and another student or the teacher makes efforts to assist that student, that signified support. It also suggests that when students have the opportunity to discuss mathematics with one another, refining and critiquing each other's ideas and understandings, and helping reshaping such ideas to produce better understanding among the group of the students; then this could also signify support. This suggests that the amount of support the teacher provides to his students during classroom instruction must be commensurate to the needs of the students. This section discusses the support the students enjoyed during their classroom instruction.

6.5.1: Sources of Support

The focus group students suggested that support during mathematics classroom teaching can come from different sources. They were of the view that this support could be from the teacher supporting the students or the students supporting the teacher or students supporting one another. The students were of the view that the central focus for any effective support in the class is to influence effective engagement and to make sure students learning is not affected. They were of the view that this support should cut across all the members of the classroom community:

> *Support must not only come from the teacher to the students, it could be between students and also from students to the teachers. (Janet: Focus Group 3: 2011)*
>
> *Support is not restricted to the teacher alone…; students can support one another…, Abi sir…, is it not true? It doesn't matter where the support is coming from...; Support is support whether from the teacher or from us the students. (Julie: Focus Group 3: 2011)*

The focus group students were able to identify and enjoyed three sources of support created and provided by the participating teachers during their classroom instruction and this helped their classroom engagement and provided a profitable atmosphere for learning.

Teacher-Student Support: The first source of support identified and enjoyed by the focus group students was what they called 'teacher-student support'. This is the type of support a teacher gives to students. This could be in the form of helping or guiding the student to find the solution to a mathematics problem or giving assistance to students with particular needs. The focus group students identified and enjoyed this type of support during their classroom instruction. For example, one of the students explained that the mathematics teacher brought graph books to the class which helped students without the graph sheet do some of their classroom assignments. Some of the comments the students made include:

> *When he was treating graphical solution to quadratic equation he brought graph sheets for students in the class that is support…, you know…, students were encouraged. (Michael: Focus Group 2: 2011)*
>
> *The teacher showed support to us…, he moves from group to group to offer academic assistance to weak groups. (Julie: Focus Group 2: 2011)*
>
> *There was support, he asked students questions and when they did not know the answer he helped them. (Jane: Focus Group 1: 2011)*

***Student-Teacher Support*:** The focus group students were of the view that support should not be restricted to teacher-student: there are situations where mathematics teachers also need support and students are supposed to show such support to their mathematics teachers. However from the data collected even though there was no example relating to student-teacher support; the focus group students identified this as an important part of classroom support.

> *Support must not only come from the teachers to students, it could be students to students and it could also be from students to teachers. (Janet: Focus Group 3: 2011)*

Another student was of the view that:

> *Even though there was not much of student-teacher support, though only within the topic, yet social support is not restricted to the teacher alone, students can support their teachers. (Julie: Focus Group 3: 2011).*

***Student-Student Support*:** The last source of support is the one the students called student-student support. This is the support that students give to one another to make sure their classroom participation is not affected. From the perceptions of the focus group students this type of support was implemented in their classroom, and it aided their classroom engagement:

> *Students showed support to one another, this is because students were found supporting one another in the class, the students were seen working together and offering academic support to weak groups. (Julie: Focus Group 2: 2011)*

An illustration of what constitute student-student support was also explained by one of the students. This suggests that the amount of support students provides to one another during problem-solving helped create a positive response to the needs of their colleagues.

> *Support is not a one line affair, the giving of money, pen or graph sheets… but, you can give somebody your notes to copy, that is support, or, if a teacher writes something on the board; I have finished…, you have not finished…, and the teacher decided to clean the board to write another thing and you asked me to give you my notes to copy … if I do…, that is support. (Micah: Focus Group 3: 2011)*

6.5.2: Types of Support

Another thing the focus group student observed during the research was the type of support they received or gave during classroom instruction. Many types of support students that can receive or give during mathematics classroom practice were identified by the students. However, academic and social support were demonstrated during the classroom instruction of the participating teachers and the students enjoyed both. Julie said,

> *There was both academic support and social support. Whether we show it in the class or outside the class it's still support, as long as one makes a member of his class happy. (Julie: Focus Group 3: 2011)*

This suggests that when mathematics teachers built their classroom instructions on cooperation and mutual support, a supportive classroom environment is usually created. This provides students with a comfortable environment to pursue inquiries and express themselves profitably during classroom instruction. It also helps students take responsibilities for not only their own learning but that of their colleagues. It also prepares them to pursue and try out new ideas.

Academic support: From the observations of the focus group students, academic support was enjoyed during their classroom instruction. For example, they were able to provide academic assistance to one another. Students who needed further explanation on particular aspects of the topic treated during and after classroom instruction were always helped. This suggests that when a mathematics teacher creates a classroom full of support, students with learning challenges are helped and assisted.

> *The teacher implemented academic support…, he moves from group to group to offer academic support to weak groups. (Julie: Focus Group 2: 2011)*

However this study suggests that support is not restricted to giving out of things it rather involves academic assistance offered to make learning rewarding and profitable to other students. It also suggests that the component of support involves teachers and their students supporting other students to achieve success as they move through the learning process. This is about recognising that all students have different abilities and also acknowledging and valuing the effort each student puts into improving their work and helping such students make the maximum use of such efforts. Janet was of the view that:

> *Support must not be restricted to giving of things; Like…, lending of pen…, there are many other ways we can show support to others students, you can explain something to another students, for example, somebody did not understand something and you that understand it better you explain it to the person- that is support., it could be helping the slow learners in the class. (Janet: Focus Group 3: 2011)*

Social Support: The focus group students reported that; they did not only enjoy academic support from their colleagues and from their teachers during classroom instruction. They were also of the view that the participating teachers provided opportunities for them to demonstrate social support during their classroom instructions. Social support which could also be call emotional support- is the type of support one person gives to another in the form of emotional assistance.

> *Social support is like showing concern to someone in need in the class, somebody's biro is finished and you share an extra biro that you have with that person is support. (Micah: Focus Group 1: 2011)*

6.5.3: Benefits of Support

From the data collected, the major reason for showing support during mathematics classroom practice is to make both the giver and the recipient of the support friendly. This suggests that support brings about happiness among students and gives them a feeling of belonging. Julie supporting this by saying,

> *..., whether we show it in the class or outside the class it's still support, as long as one makes a member his class happy. (Julie: Focus Group 3: 2011)*

The focus group students were of the view that support makes them feel secure and protected, and that there was this feeling that someone is very close to you to offer assistance when you are in need. Jane claimed,

> *It's like someone is always there… very close to you… to say, O Girl? Is there any problem? (Jane: Focus Group 3: 2011)*

Finally, the focus group students were of the view that support should be given with an open mind and not to belittle the recipient. This suggests that our attitude to one another during support should not be that of allowing self-aggrandizement, but should be that of showing benevolence to one another as is needed in a community of love and friendship.

> *Just as it is said, "your right hand should not know what the left hand is doing…, right? I can give out my pen to my friend without you knowing. Our support should be self-less. (Micah: Focus Group 3: 2011)*

6.6: Students' Views on the Resulting Inclusive Classroom

The initial perception of focus group students before the research was that most classroom activities of their mathematics teachers in their classes were teacher-centred. Their teachers sometimes kept talking in the class not minding if the students are following them on not. The focus group students asserted that they sometimes discovered that they were lost and not following the teachers during classroom instruction and that they found it difficult to understand what the teachers were saying. According to the focus group students, their teachers never bothered about it, and said that the students were sometimes scared due to the unfavourable classroom climate created by the teachers. One of the students raised this during the workshop,

> *Sometimes the way the teacher approach the students makes them dislike mathematics and indeed the mathematics teacher. I mean the teachers approach to the student is not friendly. Some students sometimes feel humiliated and sometimes say the mathematics teacher is wicked. He is not friendly and hence they will not like his teaching no matter how good he is. (Mike: Workshop: 2011)*

However, the focus group students were of the view that students' inclusion was one of the efforts the participating teachers made to aid students' engagement right from cycle 1 of the research, particularly in Jennie's classroom instructions. Inclusion means the ability of the teacher to make sure every member of the class is involved during classroom instruction. This was demonstrated during the mathematics classroom instruction of the participating teachers and the students asserted that they enjoyed it. They felt they belonged to a society where the teachers respected them and they respected their teachers also. Some of the comments made by the students include:

> *There were good teacher-student relationships in her mathematics classroom practice which made her lessons lively and interesting. There was inclusivity; meaning every member of the classroom community was carried along and every set of the class was identified and recognised. (Michael: Focus Group 3: 2011)*

Another student was of the view that from the classroom practice of one of the mathematics teacher, the low achieving and non-participating students were encouraged to be involved in the classroom instruction. That is, those students who did not really want to contribute anything during classroom instruction were encouraged to contribute their ideas to the success of the class. The focus group students asserted that the participating teacher motivated these set of students and got them engaged. The students were also of the view that the teacher considered their opinions and that these opinions were respected. This teacher's actions made the classroom instruction all inclusive, lively, and engaging. Julie supported this by saying,

> *From the way she (the teacher) was teaching I like it. The dormant group were fully recognised and carried along. Every student's opinion was respected…; the teacher was (like), making sure everybody is carried along and should be able to solve problems. This means she wanted everybody to be involved. (Julie: Focus Group 3: 2011)*

The perception of the focus group students also suggested that when students' feelings are considered in a mathematics lesson, classroom barriers such as gender, religion, tribal and peer group sentiments are usually not involved. Students studied together for the growth of the group and the community to which they belong, not minding their differences. Micah supported this by asserting that, *The mathematics teachers knew what they were doing…, they were able to make sure that everybody was included. There was also cultural integration in the class, where the grouping the teachers did was not based on tribe or religion, the students were scattered to sit with other students not based on the fact that this is my friend or not my friend. (Micah: Focus Group 3: 2011)*

The ability to identify the various sets in the class was another lesson learnt from the data collected. The focus group students were of the view that the participating teachers were able to identify the needs of the boys and the girls, low and high achievers, different cultures represented in the class and the different tribes. The mathematics teachers were able to do this because of the grouping system they adopted. Some of the comments made by the students include:

She was able to identify the sets of people in the class…, she identified the sex or the gender of the students in the class…, the gifted and the slow learners…, those willing to learn and those not willing to learn…, she made the students feel comfortable and at home with her during her mathematics classroom practice. Generally everybody in the class feels recognised and involved. (Micah: Focus Group 1: 2011)

Another student also said,

She is friendly…, she carries everybody in the class along…, she recognises the different kinds of people in the class, nobody feels inferior or superior, boys and girls were recognised and respected. (Julie: Focus Group 1: 2011)

Another student was of the view that the teachers were able to motivate the female students to feel that they too can be good in mathematics. The general perception of the students in this class was that male students do better than female students in mathematics. But the participating teacher used inclusion to discourage this view among the students. The teachers motivated the female students to face the challenge and the students were happy and encouraged according to the views of Janet.

The teacher was he kind that encouraged the girls in the class, that they can also do well in mathematics and even better than the domineering boys. She recognises the presence of female students in the class, not that the boys were neglected, but because she carried everybody along and nobody was left *behind. As it is generally believed that boys are usually regarded as the mathematics GURUS because everybody believed that girls are always left behind in mathematics. But she made us to understand that it is not true, we female students can do it also and even better, so the girls were encouraged by her reactions to us and also seeing a female teacher teaching mathematics was also a world of encouragement in the part of the girls in the class. (Janet: Focus Group 1: 2011)*

6.7: Summary

This chapter analysed the data related to the research aim that had to do with the perception of students on their engagement during the implementation of the framework. Section 6.1 of the analysis looked at the benefits that the students obtained from collaboration during their classroom engagement. This was demonstrated in the following areas. First, the students were able to identify the changes in the classroom instruction of the participating teachers from the traditional classroom setting where they are mere recipients of knowledge to a more collaborative classroom where knowledge is shared among students in the class.

Similarly, the analysis demonstrated that the focus group students had opportunities for collaboration of ideas among peers during their teachers' classroom instruction. The students also enjoyed thinking together, sharing their thoughts on how to come up with the solution to the problem. The students were of the view that collaborative thinking is a better way to solve difficult mathematics problems, a view which relates to the Intellectual Quality dimension of Productive Pedagogies. Another benefit identified by the focus group students was their active participation in the classroom activities. They were of the view that, instead of being mere passive recipients of knowledge as commonly upheld by their mathematics teachers, they were actively engaged in creating and constructing their knowledge through active participation which made them contributors of knowledge.

Section 6.2 of the analysis described students' engagement in problem solving during the classroom instructions. The focus group students enjoyed the classroom instruction as they were engaged in profitable problem solving activities. This was demonstrated in the following areas. First the students were given the opportunity to be responsible for their learning. The participating teachers allowed them to work in groups, find solutions to their problems and defend their results or solution to the whole class. Similarly, this problem solving made the students feel responsible for their learning and indeed helped them take risks and take initiatives in identifying ways to find solutions to their problems.

Section 6.3 discussed the quality of classroom interaction that existed during the participating teachers' mathematics classroom instruction. In this section the students were able to relate their interactions during the implementation of the framework compared to their previous classroom instructions. Three basic things were identified in the analysis in Section 6.3. First the focus group students were able to identify four types of classroom interactions that existed during their mathematics classroom lessons. These included what they called teacher-chalk interaction, teacher-student interaction, student-teacher interaction and student-student interaction. They, however, promoted the interaction that existed between students as the best form of interaction that should be encouraged during classroom instructions.

Second, the students also identified what the researcher called formats for classroom interactions; the students identified two of these forms. These included whole class interaction which takes place during classroom instructions with the teacher leading and guiding it. There is also what the students called group interaction which should exist between students, sitting in groups, interacting, and finding a solution to their classroom problem with the minimal involvement of the teacher. Third, one major observation of the analysis was the view of the students on classroom interactions. The focus group students and the participating teachers initial view during the workshop was that classroom interaction could be seen as distractions to the teacher and hence should be discouraged and discontinued.

However when the teachers strengthened their pedagogies through the Productive Pedagogies framework it was discovered that classroom interaction is an effective and essential tool that mathematics teachers could use to achieve quality and profitable mathematics classroom instruction. Their classrooms were interactive and yet there were no distractions for the students. Every group was busy finding a solution to their problems. Finally the analysis also demonstrated that there were benefits that the students'- obtained during classroom interactions. They identified these as making learning more interesting and student-centred as against the traditional teacher-centred classroom instructions that had pervaded and dominated the Nigerian mathematics classrooms.

In Section 6.4 the analysis discussed the students' relationships during classroom engagements. This was extensively discussed during the focus group discussions as the students were happy to have their mathematics teachers relating freely with them and also encouraged other students to do the same. In the traditional Nigerian mathematics classroom setting, students tend to view their mathematics teachers as unfriendly and authoritative during classroom instruction. During this study, student saw a new approach to classroom instruction and appreciated it. They were of the view that the classroom environments created by the participating teachers were relaxed and friendly. The focus group students identified two forms of relationship they enjoyed including teacher-student relationships and the student-student relationships. The benefits the students obtained from these relationships demonstrated that students' engagement was beneficial to their classroom participation through the friendly atmosphere created by the participating teachers. Some of the benefits discussed include making the students feel respected and recognised by their teachers.

In Section 6.5 the analysis demonstrated the atmosphere of support that prevails during classroom engagement. The analysis in this section was divided into three subsections which include: the sources of support, the types of support and the benefits obtained through support. First, on the sources of support, the focus group students identified teacher-student support, student-teacher support and student-student support. Second, the students identified two types of support that they enjoyed during the participating teachers classroom instructions which they described as academic and social support. Third, the benefits of support were discussed in the analysis. Prominent among them was that support is aimed at making both the giver and the recipient of the support happy which brings about happiness among students.

Finally, Section 6.6 looked at the resulting inclusion that existed among the students during their classroom engagement. First, the students were able to bring out their own definition of inclusion to mean the ability of the teacher to "carry-along" every member of the classroom community during classroom teaching. The students felt included into the classroom community created by their teachers. They were also of the view that the participating teachers respected them and that this contrasted with the traditional classrooms where they had no voice and their views were not considered. Second, the students were also able to support their colleagues, especially students with learning challenges. Third, the students were of the view that there was an atmosphere of inclusion during their classroom engagement. This is because their teachers identified differences in socio cultural groups in their classes and worked hard to meet their individual needs.

CHAPTER 7

DISCUSSION AND CONCLUSIONS

7.0: Introduction

Attempts to compile a list of principles of quality pedagogies have been around for about two decades from the time of the Authentic Pedagogies of Newman and associates to the Queensland education reforms on Productive Pedagogies. However, there is no evidence in the literature that the concept had been explored in Nigeria. Nevertheless, certain principles of the framework have been explored by Nigerian educational researchers. For example, Bature and Bundot (2009) have proposed developing the classroom climate for effective mathematics classroom instruction which is in line with the Supportive Classroom Environment as discussed by the Productive Pedagogies framework. Kalu (1997) worked on classroom interaction patterns among secondary school students which could be in line with the element of substantive conversation of Intellectual Quality in the Productive Pedagogies framework. Five research aims guided this research. These included investigating:

1. The scaffolding needed by participating teachers to implement the Productive Pedagogies framework;
2. The changes in participating teachers' classroom practice as a result of the implementation of the Productive Pedagogies framework;
3. The participating teachers' reflections on the effects of the Productive Pedagogies framework on their practice.
4. The perceptions of students on the effects of the Productive Pedagogies framework on their engagement.

5. The challenges that participating teachers encountered while introducing Productive Pedagogies.

This study was conceptualised in two phases. In Phase 1, four participating teachers taught a Senior Secondary School 2 mathematics class for a period of ten weeks as part of the practical teaching during their upgrading course. Their classes were observed using the QSRLS Productive Pedagogies Classroom Observation Manual (Education Queensland, 2001) through what was described in Chapter 3 as peer observation. There were also planning and reflection meetings with the researcher after every two weeks of teaching and observations. A sample of six students in the classes constituted the focus group. The researcher had three focus group discussions during the ten weeks of research with these students. Other sources of data in Phase 1 included the researchers' observations and Casual Interviews with the participating teachers.

In Phase 2 of the research, three participating teachers were followed in their secondary schools. Two secondary schools were used in two different states in Nigeria as indicated in Chapter 3. Each participating teacher was observed four times which constituted the major source of data in this Phase. In each observation, evidence of implementation of the four dimensions of the Productive Pedagogies framework was sought. There were Casual Interviews with the participating teachers and some selected students.

7.1: Addressing the Research Aims

The previous chapters reported the theoretical background, the methodology and sources of data used, and the findings of this study. This section discusses the major findings observed using the data analysed in Chapters 4, 5, and 6 using the research aims postulated in Chapter 1. The discussion concentrates on the following. First, the scaffolding needed for participating teachers to implement the framework to achieve quality classroom instruction is discussed. Second, the researcher discusses the implementation of the Productive Pedagogies framework during their classroom instruction. Third, the researcher discusses the participating teachers' reflections on the effects and benefits of the Productive Pedagogies framework on their practice. Fourth, the researcher discusses the perceptions of students on the effects of the Productive Pedagogies framework on their engagement. Finally, the researcher discusses the challenges that the participating teachers encountered while implementing Productive Pedagogies.

7.1.1: Research Aim 1

To investigate the scaffolding needed by participating teachers to implement the Productive Pedagogies framework

Scaffolding has been a useful metaphor for thinking about classroom instruction and indeed in teachers' development programs since its introduction by Lev Vygotsky (1978). This research project was designed to provide this scaffolding to support and assist the participating teachers as they gained an understanding of the implementation of the principles of Productive Pedagogies. This support was tailored towards meeting the needs of the participating teachers with the view of helping them achieve new classroom teaching strategies and/or to achieve quality classroom instruction. This is in line with the research by Wilhelm, Baker, and Dube, (2001) who believed that in teacher development programs, the developers must endeavour to provide student teachers with different theories and knowledge about teaching so that they can apply this knowledge in the classroom. The researcher is of the view that helping the teachers to link the knowledge between theory and practice should be a major concern in scaffolding.

From the findings of the research and from experience as a teacher educator in Nigeria, this aspect seems to be lacking in the Nigerian teachers' development programs. This is because teacher development programs seem to be too theoretical and not helpful for novice teachers to understand those pedagogies needed to develop effective classroom instruction. This problem necessitated the scaffolding in this research. The researcher was not only interested in helping the participating teachers acquire theoretical knowledge of the framework, but to also have the practical knowledge on how quality classroom teaching strategies could develop.

The findings of the study suggested that the scaffolding provided in this research served as a tool to guide the participating teachers' shift from the traditional classroom instruction to a more student-centred learning as promoted by the constructivist theory and the government policies and desire for change for a more practical mathematics classroom teaching practice (NERDC, 2013). Such a shift was not an easy task for the teachers, which necessitated ongoing scaffolding. This point is consistent with the views of Clark (2005) who lamented that most mathematics teachers rely mostly on knowledge transmission approaches during classroom instruction as a result of their previous learning experiences. Tatto (1999) suggested that teachers' development programs should help the teachers to understand the theoretically grounded view of learning that shifts from the traditional conceptions of knowledge as 'being given' to knowledge developed by those who are involved in learning.

The challenges of this shift from the traditional teacher-centred instruction to the more student-centred approach by the participating teachers perhaps could be as the result of the relative short time during which the project was implemented. The Productive Pedagogies framework was a new concept to the participating teachers and to the Nigerian classroom; the two days' workshop perhaps was not enough for them to learn all the principles and practice of the framework. Therefore the findings of the study revealed that the participating teachers needed continual support and assistance on how to use the principles to improve their instruction.

Vygotsky viewed scaffolding as the role of the facilitator in supporting development and providing the necessary and effective support structures that will help teachers' development to move to the next stage or level (Raymond, 2000). This was demonstrated in the research because the study revealed that as the participating teachers' knowledge, abilities and understanding of the principles of Productive Pedagogies increased, there was an increase in their ability to implement the framework as a result of the scaffolding provided. One of the participating teachers said,

> *There is bound to be some nervousness and even lapses in the implementation of Productive Pedagogies at the initial stage, because this is the first time we know this. Hence in its implementation there are bound to be some initial nervousness, lapses, and mistakes. I think as we grow from cycle to cycle we shall develop some more stamina to do well. (Jerry: Reflection Meeting 1: 2011)*

Another participating teacher also said,

> *We started slowly and were working alone, but as we continued we will develop some confidence to get the students involved in what we were doing…, we really need to sit and think on the strategies to use in motivating ourselves and our students before coming to class…, we have to study harder also so as to know how these elements could be implemented. (Jackson: Reflection Meeting 1: 2011)*

The findings of the study also suggested that the scaffolding given provided the participating teachers with conceptual, material and linguistic tools that supported their understanding and implementation of the Productive Pedagogies framework. These conceptual, material and linguistic tools were in the form of literature, and research articles from the extant literature. They were also in the form of discussions, dialogues and interaction that the researcher had with the participating teachers during the workshop, reflection meetings and in several one-to-one discussions. The implications from these varieties of scaffolding helped the participating teachers develop new understandings by linking their prior knowledge about classroom instruction with the principles of the Productive Pedagogies framework. This prior knowledge and understanding according to Knezic (2011) became the subject of discussions, debates and deliberations through interaction between participants. One of the teachers was of the view that,

> *Discussions and dialogue allow us teachers to have thoughts we could not have had on our own, yet to recognise these thoughts as developments of our own thinking. (Jackson; Casual Interview: 2013)*

Notes from Research Journal also suggested that,

> *when problems are generated we all discussed together to find a common approach that could be used to address such problems, this helped me to approach my research with a sense of belonging (knowing) that there are people who will support, encourage and criticise you at each stage of your work. (Research Journal: 2011)*

The findings of this study suggested that the talk (theory) embedded in the actions (practice) of the participating teachers as observed in the study provided opportunities for the teachers to regulate the language and practice of one another on the Productive Pedagogies framework to foster better understanding. From the Vygotskian perspective, dialogue between colleagues may range from casual talk to deliberate explanations about features of tasks to be performed (Dorn, 1996). Similarly, what may seem to be casual conversational exchanges between two or more people could actually offer more opportunities for fostering cognitive and language development (Clay 2005; Lai & law, 2006).

Smagorinsky (2007) was also of the view that conversations between two individuals could facilitate generative, constructive, experiential, and developmental learning in an attempt to develop new ideas and knowledge. While Applebee (2002) believed that effective scaffolding provides opportunity for task-based dialogue between two or more participants which provides them with the opportunities to use their old knowledge and strategies necessary to complete and understand new tasks and principles and helps them to internalise the new knowledge and skills for eventual use in future tasks.

7.1.2: Research Aim 2

The changes in participating teachers' classroom practice as a result of the participating teachers' implementation of the Productive Pedagogies framework;

The participating teachers in this study attempted adopting the Productive Pedagogies framework into their mathematics classroom instruction. This was intended to find out if their practice could help them achieve quality and effective classroom instruction. In this section, the participating teachers' implementation of Productive Pedagogies in their classroom instruction and some possible limitations they encountered while implementing the framework are discussed.

Achieving the Productive Pedagogies Framework: The data collected demonstrated that the participating teachers made conscious attempts at implementing the Productive Pedagogies framework during their classroom instruction. These attempts were demonstrated and analysed in Chapters 4, 5 and 6. For example, the data collected suggested that implementing substantive conversation during classroom instruction helped students solve high Intellectual Quality problems, and thereby helped students gain a deeper understanding of the content discussed.

This finding suggested that mathematical knowledge is developed through effective substantive conversations between students. Through students' mathematical conversations, knowledge of mathematics concepts are deepened. This is because students generate questions which encouraged further dialogue and discussions during classrooms instruction (Frykholm & Pittmman, 2001). Similarly, Corwin (1997) suggested that by talking, students clarify their ideas and their doubts about difficult mathematical issues that bothered them or that they found difficult to resolve. While McClain, McGatha and Hodge (2000) were of the view that substantive conversation among students supports the development of mathematical arguments which assists students to have the opportunity of explaining their justifications and developing their ways of reasoning to support their analysis.

Similarly, the findings of this study suggested that the participating teachers utilised problem solving activities to engage their students in solving problems. The participating teachers were able to encourage their students to use problem solving strategies to reconstruct the question in their own understanding and come up with appropriate solutions to their problems. Jennie supported this by saying,

> *Achieving Intellectual Quality requires mathematics teachers to give their students challenging problems to afford them the opportunity to use their thinking abilities to analyse, criticise and synthesize their knowledge. This could be achieved through problem-solving techniques as this will also engage our students in higher order thinking, and substantive conversation to solve problems on their own. (Jennie: Reflection Meeting 1: 2011)*

This statement is in line with the findings of Resnick (1987) who was of the view that problem-solving approaches contribute to the practical use of mathematics by helping students develop their own strategies when faced with challenging situations. Newmann and Associates (1996) subsequently found that when teachers provide students with intellectual challenges, the students performed better in their assessment. According to Cockcroft (1982) developing problem solving skills in students is a means of developing mathematical thinking tools and skills that students need to solve daily life-related problems and are a means by which mathematics can be applied to a variety of unfamiliar situations.

Another observation made from the study revealed that the participating teachers made efforts to ensure that classroom instruction was relevant to their students. They achieved this through the use of locally made materials commonly found around their students. This suggested that when mathematics teachers improvised, their classroom instruction became more meaningful to their students; this helped students develop, and construct meaningful and relevant understanding of the mathematical concept. The participating teachers also used common activities in their students' immediate classroom environment to demonstrate Connectedness. Jennie said during one of the reflection meetings that:

The teachers (e.g. Jackson) most a times will make use of the students to cite examples of daily happenings in society. Activities like going to the markets to buy things, students in the football field and generally things around the students were used to connect the lessons to the world. (Jennie: Reflection Meeting 2: 2011)

According to Hayes et al. (2006), when teachers make the subject matter relevant, they connect classroom learning with real-world processes, thereby making learning more enjoyable. The implication of this was that it helped the participating teachers make efforts in connecting their mathematics classroom instructions with the world beyond the classroom. The participating teachers also created activities that helped their students to create links between mathematics and their background knowledge as well as between mathematics and other subject areas thereby helping their students' demonstrate better understanding and increased motivation to learn the content.

Another finding of the study suggested that the participating teachers made efforts to create classroom environments that enhanced their students' participation and engagement. The participating teachers achieved this by creating an enabling environment suitable for engaging students in learning. This environment provided opportunities for students to be involved in profitable engagement and discussions, helped build their confidence to take responsibility for their learning and thereby increase students' confidence during classroom teaching. Notes from the researcher's Research Journal suggested that:

Achieving quality mathematics classroom teaching using the Productive Pedagogies framework requires mathematics teachers to create an enabling classroom environment, through motivation, initiatives and creativity. This will provide students with the opportunity to make use of their higher order thinking skills. (Research Journal: 2011)

Jennie, during reflection meetings, also suggested:

> *In a situation where we are teachers and we are students; makes our students feel relaxed..., the teacher brings the knowledge and the students analysed and discussed suggesting that students' determined the direction of their learning. (Jennie: Reflection Meeting 2: 2011)*

The implication of this point suggested that in order to create a learning environment that will build students' confidence and students' engagement, mathematics teachers must create positive interpersonal relationships that honour student voices and encourage students to work together. This will provide the students with opportunities to use their own perspective in taking real and definite decisions on how their learning will take place during classroom instruction which is in line with the principles of students' direction of the Productive Pedagogies framework (Atweh, 2007).

Similarly, the findings suggested that the participating teachers identified and embraced instructional strategies that valued all students' backgrounds irrespective of social or cultural identities, to ensure that such students were successful during mathematics classroom instruction. For example, notes from the Research Journal suggested that:

> *Provision of sufficient social support, equal access to mathematics learning resources, and provision of the enabling environment to the disadvantage students in the mathematics classroom contributed to the classroom participation of students with special needs. (Research Journals: 2013)*

This finding suggests that the mathematics teachers who organised their instruction to provide students with diverse abilities to interact with each other freely provided opportunities for such students to learn mathematics collaboratively. It also helped to create students' enthusiasm and higher levels of perseverance in their effort to resolve classroom problems. This observation also revealed that the participating teachers made efforts to provide equitable mathematics classroom instruction for all students. This was achieved through classroom organisations and interactions created by the participating teachers during their classroom instruction. One of the students commented:

> *There was cultural integration in the class, the grouping was not based on tribe or religion, the students were scattered to sit with other students not based on the fact that this is my friend or not my friend…, The teachers knew what they were doing …, they were able to make sure everybody was involved. (Micah: Focus Group 2: 2011)*

Discussion on some Limitations Observed: From the discussion above, the participating teachers made efforts to implement Productive Pedagogies during their classroom instruction. However, there were some limitations observed in their implementation of the framework. For example, the analysis in Chapter 4 showed that the participating teachers found it difficult shifting from the traditional mathematics classroom teaching to the student-centred classroom instruction. Klein (1996) observed that mathematics teachers sometimes rely so much on traditional classroom instruction where knowledge is transmitted instead of facilitated.

Perhaps, one could adduce some reasons behind such limitations. As suggested above, the participating teachers had limited time learning the framework and its implementation, shifting from what they are accustomed to, to another approach of classroom teaching is rather challenging. In particular, the data collected demonstrated that the participating teachers initially felt that releasing classroom control to their students could be counterproductive to effective classroom instruction.

> *The truth is that for effective teaching in my view is the mathematics teacher must dominate and control the classroom activities. If not sir…, one will find*

> *it difficult finishing what he has prepared for the class. (Jackson: Reflection Meeting 1:2011)*

Another difficulty the participating teachers had was the limited ability to implement some elements of Productive Pedagogies. The findings of the study revealed that the participating teachers either applied some elements wrongly or they lacked technical abilities to effectively implement such elements. For example, from the researcher's observation of Jackson's classroom teaching in Phase 2 revealed that only lower order thinking skills were exhibited or explored during his classroom teaching. The activities provided did not pose any challenge to the students at their level of schooling. Perhaps, one may argue that this was Jackson's first class with the students and as such he might have not had the basic knowledge of their abilities. However, this should not be an excuse for any mathematics teacher to provide unchallenging classroom activities for his or her students. Jackson should have also understood that most science classes in Nigerian Senior Secondary Schools are generally regarded as having students with above average achievement.

In defending his action, Jackson was of the view that students from the school were from poor socio-economic backgrounds and could not be given content that is far above their abilities. He argued:

> *Because of the level of these students I mean students from low socio economic background and from the semi-urban society like Kafanchan, one cannot compare their abilities with the students in Bauchi who are from an urban society and from a better and higher socio-economic background. (Jackson: Reflective Interview: 2013)*

Perhaps Jackson has fallen into the trap that many teachers in mathematics are likely to fall into, which is contrary to the very basis of Productive Pedagogies. This is related to the findings of Way (2008) who suggested that teachers raise few questions to discourage the use of higher order thinking skills during instruction because they felt their students are inexperienced in such tasks. Similarly, Alsharif (2012) observed from the findings of his study, that the teachers he used were of the view that engaging students in higher order thinking was not an easy task for them. However, one of the principles of the Productive Pedagogies framework suggests that teachers should not attempt to reduce the quality of what the students are to learn because of their socio-economic status, gender or learning abilities.

Another example was that the participating teachers had difficulties implementing metalanguage in their classroom teaching. Metalanguage, which could be regarded as the pedagogies that incorporate frequent discussion about talking and writing, was implemented to a limited extent in most of the teachers' classrooms observed in this research. The participating teachers also stressed difficulties while attempting to incorporate discussion about talking and writing into the mathematics classroom.

> *The teacher needed to improve on the usage and application of this metalanguage of the thing, because it was not really well implemented. (Reflection Meeting 3: 2011)*

Alsharaf and Atweh (2011) were of the view that some of the teachers in their own research also had difficulties illustrating metalanguage principles into their mathematics classroom instruction. This was due to the limited experiences of the teachers in their study. Similarly, as discussed earlier in this study, a two day workshop was not enough for participating teachers to understand all the principles and practices of the 20 elements of Productive Pedagogies and implement these in their classroom instruction.

Another challenge was that the participating teachers had difficulties implementing connectedness to the world in some mathematics topics, particularly abstract mathematics concepts. The findings suggest that the teachers identified challenges demonstrating or achieving connectedness to the world in some topics in mathematics that do not lend themselves to simple everyday applications such as surd, rational and irrational numbers and the development of quadratic formula. According to the participating teachers, these topics were too theoretical and abstract in nature. Therefore, relating them to the world was not easy. From the researchers notes recorded in the Research Journal, the researcher stated that:

> *While the major problem the teacher had, based on what students raised, was that the work was abstract, and there was no way he could have related the derivation of quadratic formula with the world. He was just in the class to develop the formula, how do you relate the quadratic formula with the world? Asked the one of the students? (Research Journal: 2011)*

Finally, the study also revealed that some elements of the framework were completely absent from the classes observed in this research. For example, the elements of narrative in Recognition of Difference and explicit quality performance criteria of Supportive Classroom Environment dimension were absent in the teachers' discussions. Arguable, it is as a result of the participating teachers' inexperience in these pedagogies and (Way, 2008) was of the view that the absence of such discussion in the mathematics education exists in the literature. Similar comments were made in Saudi Arabia by Alsharif and Atweh (2011) who found in their research that some of the teachers indicated that certain elements of Productive Pedagogies framework were not easily applied.

7.1.3: Research Aim 3

To investigate the participating teachers' reflection on the effects of the Productive Pedagogies framework on their practice

Mathematics classroom instruction in most Nigerian classrooms is a predominantly teacher-centred teaching approach commonly called teacher-domineering approach by some Nigerian mathematics teachers, educators and researchers (Afolabi & Abimbade, 2012). This teacher domineering teaching approach gives no opportunity for students' participation and/or engagement (NERDC, 2013). Igbokwe (2000) argues that Nigerian mathematics teachers generally view themselves as having the monopoly of knowledge (meaning they possess all the knowledge that the students need to know).

The findings of this study suggested that there was an observable shift from this traditional teaching approach as reflected by the participating teachers. This section discusses the reflections of the participating teachers on the changes observed. First, the section discusses the change towards the student-centred teaching. Second, the change in students' attitude towards mathematics and mathematics teaching and learning is described. Third, the changes in teacher-student and student-student relationships are presented and described.

Change Towards the Student-Centred Instructional Approach: The findings of this study suggested that teachers reflected on the changes that they observed in their teaching approaches. From their reflections, the teachers were of the view that adopting the Productive Pedagogies framework provided an opportunity for them to create a classroom atmosphere that brought about improved classroom instruction. The principle of the student-centred approach in Nigerian classrooms is not new to classroom teachers. A series of workshops and professional development programs have been organised to update teachers' pedagogical development especially in using the student-centred instructional approaches (NERDC, 2013). However, most mathematics teachers and indeed most teachers generally seem not to have attempted demonstrating it in their classroom instruction (Emaikwu, 2012).

However, there is evidence that the participating teachers did not only perceive the framework as influential in challenging their views on effective classroom instruction, but it also had a significant influence on their practice as teachers. This is in agreement with the findings of Alsharif (2012) who suggested that teachers' personal views on learning theories have significant and important influences on their classroom teaching. One possible avenue that mathematics teachers can use learning theories to improve their classroom instruction is by shifting their beliefs about the effectiveness of mathematics classroom instructional strategies.

From the reflections of the participating teachers and the researcher's observations of the classroom instruction of the teachers, considerable evidence exists in the study that the application of the Productive Pedagogies framework influenced the participating teachers' classroom instruction by challenging their personal views about mathematics classroom instruction. For example, one of the views that were previously upheld by one of the participating teachers during the workshop was the need for teachers' control of the classroom.

> *When the teacher is in the class, he is supposed to be in control of all the activities in his class. He should be in-charge of directing all the affairs of his class; allowing students to take control of the classroom activities might be counterproductive (Jackson: Workshop: 2011).*

The participating teachers, however, reflected that their views of mathematics classroom instruction shifted after discussing with colleagues during reflection meetings and also due to the comments raised by the focus group students about the importance of involving students in classroom instruction. These comments suggested the necessity for the shift from the teacher-control and overbearing mathematics classroom to a more democratic classroom.

> *We did not tolerate their misbehaviour; I did not really allow students interaction during my classroom practice. I insisted they should be quiet in the class and listen when I am teaching. With these comments in the next class I will try to be friendlier and allow students some level of freedom in my class. (Jennie: Reflection Meeting 1. 2011)*

Hence, this suggested that there was a shift in both their views and application from the traditional teacher-centred classroom to a more student-centred classroom. This is in agreement with the views of Wilson and Lloyd (2000) who suggested that the pattern of classroom instruction can be altered if mathematics teachers and their students are willing to change their roles and beliefs.

The findings of this study suggest that the participating teachers observed some improvements in their practice as they attempted using Productive Pedagogies to improve their classroom instruction. Prominent among their observations was the diminishing nature of their classroom-control which gave room for a more democratic mathematics classroom. The implication of these observations suggested that the introduction of Productive Pedagogies in the participating teachers' classrooms reformed their classroom instruction to a more student-centred classroom environment (Atweh, 2011). This gave the students the opportunity to have some control over their learning. It also created opportunities for students to approach their teachers and their classmates to seek assistance during classroom instruction. Jackson testified:

> *My classroom used to be like a graveyard…, students dared not talk when I was teaching…, but to my amazement as I introduced Productive Pedagogies framework in my class, the class naturally became interactive, the students interacted in their groups, and before you knew it, the solution to the problem*

was gotten and even those who feared mathematics were ready to defend their answers. (Jackson: Focus Group 2: 2011)

***Change in Students' Attitude towards Mathematics and Mathematics Teaching**:*

The findings of this study suggested that there were observable improvements in students' attitude to classroom instruction. Generally in most mathematics classroom instruction in Nigeria, there is a lack of interest towards mathematics by students. As earlier indicated in this study, mathematics students had developed negative attitudes towards mathematics and mathematics classroom instruction. Researchers have suggested possible causes of these negative attitudes to include poor teachers' pedagogical strategies and approaches to classroom instruction (Oguniyi, 2009; Osuafor, 1999).The participating teachers reflected that adopting the principles of Productive Pedagogies during their classroom instruction provided an observable change in students' attitude towards mathematics and mathematics teaching.

Some of these observable changes as reflected by the participating teachers were the improvement of their students' interest in mathematics, increased students engagement and the willingness of students to accept responsibility for their classroom instruction. For example Jennie commented that,

There were also attitudinal changes towards mathematics as a subject, because a girl said that students now love mathematics in the class, and don't look at mathematics as that difficult again. (Jennie: Reflection Meeting 1: 2011)

Similarly, from the Research Journal it was observed that,

The students were serious and committed to their learning. From what the teachers said, they were always ready to defend the solution to their problems as against the background of fear and timidity that greeted most of their classroom in the past. (Research Journal; 2011)

The findings of this study suggested that mathematics teachers' change in pedagogy had positive influence on their students' interest towards mathematics and its teaching. Bajah (1999) was of the view that productive mathematics teachers are those that have the ability to stimulate their students' interest and have clarity of presentation of mathematical ideas to their students. Bajah went further to suggest that the important characteristics of productive mathematics teachers include good pedagogical approaches, and interpersonal traits such as helpfulness, openness, and friendliness which could be seen as ingredients for effective mathematics teaching. These pedagogical approaches, which are important characteristics of productive mathematics teachers, are clear reflections of the various elements of Productive Pedagogies.

Change in Teacher-Student and Student-Student Relationships: The findings of the study also suggest that a new friendly classroom atmosphere between teachers and students and between students was created. This was as a result of the relaxed classroom climate created by the participating teachers.

> *Establishing good and effective classroom relationship precedes effective and good classroom control or management…., our students need some elements of freedom in what they are doing in the class. (Jennie: Reflection Meeting 1: 2011)*

The concept of shift from the teacher-control of the mathematics classroom instruction to more relaxed classroom environment made learning more collaborative, more student-centred and more student-controlled in a non-authoritative way was revealed from the findings of the study. The participating teachers reflected that the change in their pedagogies encouraged substantive conversation, students' engagement, inclusive participation and students' direction during mathematics classroom instruction.

I observed that there was active participation of students in the groups; the students were busy interacting with one another in their groups on the topic. Interactivity in Productive Pedagogies is really good because it makes teaching and learning more teacher-student friendly. (Jackson: Reflection Meeting 2: 2011)

This comment suggested the importance of an embodiment of a new relationship that should exist between teachers and students and between students grounded in an ongoing dialogue, negotiations, debate and in a collaborative climate which involved participation, integration and interrelatedness between members of the classroom community (Vitto, 2003). This approach helped students share their experiences and their knowledge holistically, and celebrate its authenticity through collaboration of ideas with their colleagues. It also ensured the members of the community (students and teachers) had involvement in learning communities in which all participants have opportunities to engage in productive discourse (Manoucheri & St John, 2006). Similarly, mathematics teachers who foster positive relationships with their students create classroom environments that are more conducive for learning and this helps to foster the social, developmental, emotional and academic needs of the students (Atweh, 2007).

7.1.4: Research Aim 4

To investigate the perceptions of students on the effects of the Productive Pedagogies framework on their engagement

Mathematics engagement is represented by active involvement, commitment, and concentrated attention of students during classroom instruction (Newmann et al., 1992). This is in contrast to the superficial participation, apathy, or lack of interest of students during a typical mathematics classroom instruction (Newmann et al., 1992). The findings of the study suggested improved student engagement in mathematics classroom instruction. The tradition of students' passive involvement in mathematics classroom instruction was gradually replaced with a more collaborative, supportive, participative and inclusive students' involvement in classroom activities. This section discusses the benefits reflected by the students on their perceptions of engagement in mathematics during the implementation of the framework.

The data collected during focus group discussions and Casual Interviews with the students suggested that the students enjoyed the classrooms created by the participating teachers during their implementation of the framework. First, from the views of the students, the participating teachers created opportunities for collaboration between students during their classroom activities. This helped students' involvement in classroom activities and provided opportunities for more student-directed and actively participatory mathematics classroom instruction. Hence, the students were not mere passive recipients of knowledge. Rather, they were engaged in creating and constructing their knowledge through collaboration of ideas, thereby creating opportunities for active engagement during classroom instruction.

> *The collaboration between students was good ..., because in solving problems in the class when I have the idea of step one…, other students have the idea of step two… step three…, when we put the ideas together it helps us get the solution faster. (Research Journal, 2013)*

Similarly, the findings of the study also suggested that in this type of mathematics classroom students are involved in sharing their ideas with their colleagues, provide support and show concern for their classmates. This is in agreement with the findings of Simon (1995) who suggested that mathematics classroom instruction where students ideas are solicited, shared and valued as important contributions to developing understanding of concepts and problems, gives students the privileges of developing their own algorithms, construct their own knowledge and become responsible for their own learning as against the dominant role played by mathematics teachers in these classrooms.

Simon (2006) suggested that teachers become collaborative members and the classroom environment or climate revolves effectively as a result of collaboration through interactions that is going on during classroom instruction. Similarly, in such classrooms, the mathematics teacher's role changes and is geared towards a supervisory role (Ross, McDougall & Gray, 2003) rather than the teacher-centred classroom control commonly experienced by students in most Nigerian mathematics classrooms.

Another perception of the focus group students from the study suggested that the participating teachers engaged the students in profitable problem solving. This provided opportunities for students to learn and attain deeper and richer understanding of mathematics using the problem solving classroom climates created by the participating teachers.

> *This is not only you alone thinking on how to solve a particular problem, the thinking is in a group; by the time we join our heads together and think on a solution to a particular mathematics problem, you bring your idea… I bring my idea…, the solution becomes easier. (Julie: Focus Group 3: 2011)*

When students are fully engaged in profitable problem solving activities, allowed to work in groups, share ideas with their mates, challenge one another's thoughts and defend their results or solutions to the whole class in their effort to find a solution to their mathematics problems, this sometimes makes students enjoy the classroom instruction, pay attention to classroom instruction and in the process learn and achieve more. Lampert (1990) supported the view of the students above by suggesting that as students explain and justify their thinking and challenge the explanations of their peers, it helps them to be engaged in clarification of their own thinking and becoming owners of the knowledge they created. This observation suggested that profitable learning takes place through the process of sharing ideas, collaborating with members of the classroom and thereby helping students learn relevant mathematics concepts. Skills are also developed or built by such students during classroom instruction (Schoen & Charles, 2003). This student said:

> *Grouping us made us identify some good things others know that we don't know…. I discovered we all worked with passion and made everybody be involved…, whatever idea you have you simply say it and nobody said anything against it but rather your simple ideas were digested and helped lead to the solution…, (Research Journal: 2013)*

The findings of this study also suggested that the participating teachers provided opportunities for effective teacher-student and student-student interactions. The implication of this finding suggests that interaction provided students with the opportunities to learn certain skills that could have been difficult to learn when working alone. For example, from the researcher's Research Journals, it was stated that

> *The student may not have any idea at all…., but mixing up with other students, that is the classmates; make it easier…, the students also learnt faster than when working alone depending only on the teacher. (Research Journal, 2013)*

D'Ambrosio et al., (1995) were of the view that it is expected that when students are engaged in such mathematical talk, they share ideas with their classmates or initiate questions intended for their teachers and their classmates, and that these could lead to better understanding of mathematics.

Another finding of the study suggested that the participating teachers created a positive mathematics classroom atmosphere that provided opportunity for effective engagement. This revealed that fostering positive relationships between teachers and students and between students provided an effective tool that mathematics teachers could be used to increase students' engagement during classroom instruction. For example, Julie said:

> *The new classroom framework brings about good and cordial student-teacher relationships; In fact it brings about good relationships also between the students. I wonder how this change was so natural and dramatic. (Julie: Focus Group 3: 2011)*

Morganett (1991) supported this view by suggesting that fostering teachers' positive and supportive relationships with their students tends to help students' performance during classroom engagements. This also suggests that students who feel personal connections with their teachers and colleagues, experience frequent communication, receive more guidance and praise than criticism from their teachers, tend to become more trustful, confident and free during classroom teaching and this thereby increases their participation and engagement during classroom instruction. Janet said:

> *Students really need a free and fair classroom where everybody will have the opportunity to approach the teacher on areas of misunderstanding…, and the teacher created this atmosphere in cycle 2. So in short the teacher improved. (Janet: Focus Group 2: 2011).*

The findings of the study did not only suggest the effectiveness of teacher-student relationships, but the study also suggested improvement in student-student relationships. The focus group students were of the view that effective student-student relationships gave birth to an atmosphere of friendship and unity among students during classroom engagement and indeed generally. Janet said:

> *The classroom environment created by the teachers brings about unity and love among us (students) in the class, which brings about excellent cooperation between students and between teachers and students. (Janet: Focus Group 3: 2011).*

The findings of the study also suggested that the classroom climates created by the participating teachers provided opportunity for students to show support to one another. This showed that to improve students' chances for effective engagement, mathematics teachers and their students must strive to form meaningful personal relationships that are full of support and understanding. Atweh (2007) was of the view that social support in mathematics classrooms should focus on the extent to which mathematics classroom is characterized by an atmosphere of mutual respect and support. The finding of the study suggested that the students were also of the view that they were able to help their colleagues, especially those with learning challenges.

> *It's like someone is always there… very close to you… to say, O Girl? Is there any problem? Do it this way, this way, and this way… the classmates also… the teachers… are always there… willing to assist… willing to show the way. (Jane: Focus Group 3: 2011).*

Promoting an inclusive mathematics classroom helps make mathematics teachers respond to the needs of their students effectively. This point tallies with the view of Gay (2000) who was of the view that teachers' response to the needs of students tends to make students have a sense of inclusion, honour and also have a sense of human dignity, which help promote students' self-concept and improve academic and social interaction within the mathematics classroom community.

7.1.5: Research Aim 5

To investigate the challenges participating teachers encountered while introducing Productive Pedagogies.

The findings of the study demonstrated that the introduction of Productive Pedagogies in Nigerian mathematics classroom tends to show some promise as discussed in research aims 3 and 4. However despite these promising achievements made and the attendant benefits obtained, the study also identified some challenges that worked against the full implementation of the framework. This suggested that the participating teachers were not only interested on the benefits they obtained adopting the framework, but they were also able to identify some possible challenges that implementing the Productive Pedagogies framework posed to their mathematics classroom practice.

In Section 7.1.2 the researcher discussed the areas in which the participating teachers were limited in their implementation of the framework. The discussion in this section concentrates on the more general challenges that are related to the introduction of the Productive Pedagogies to the Nigerian mathematics classroom. The findings of the study suggested that one of the challenges that the participating teachers encountered during the research was the challenge of time allocated to mathematics classroom teaching in the school time table. They were of the view that the effective implementation of the Productive Pedagogies framework in Nigerian mathematics classrooms requires time. The 40 minutes mathematics classroom teaching time allocated to mathematics lessons and other subjects in the Nigerian classroom was viewed insufficient for effective implementation of the Productive Pedagogies in their Nigerian mathematics classroom. Solomon and Olugbade (2011) lamented that the insufficient time-frame for effective classroom instruction is responsible for the inability of some teachers to complete their syllabus. The participating teachers generally faced this problem and argued that:

> *For effective implementation of the dimensions of the Productive Pedagogies framework mathematics teachers need at least a double period of about 80 minutes. (Research Journal, 2013)*

Jackson and Jerry also argued

> *There is the problem of time generally; time management was not easy for us because with this Productive Pedagogies model, honestly to effectively implement it, 40 minutes is not enough for it.* (*Jackson: Reflection Meeting 2: 2011)*
>
> *I think Jackson is right sir; this needs time if the beauty of this model of classroom practice is to be clearly seen and appreciated. I think it is best for double periods not just this 40 minutes single period. (Jerry: Reflection Meeting 2: 2011)*

This teaching, however, improved in Phase 2 of the research where the participating teachers were given double periods of 80 minutes each.

Another challenge that the participating teachers had was the problem of space, despite supporting the use of Productive Pedagogies as a better alternative to handling the overpopulated classrooms in Nigerian. The researcher, however, suggested that its success depends so much on the availability of space for effective collaboration and interaction between students during classroom activities. This suggested that when there is free space for within-group and inter-group interaction between students during classroom instruction as discussed in above, Production Pedagogies remains an appropriate alternative for Nigerian overpopulated classrooms.

7.2: Implications of the Study

This study made a concerted effort to contribute to research studies in mathematics classroom teaching with particular reference to Nigerian secondary school mathematics. The desire to achieve quality classroom teaching in Nigerian secondary schools necessitated the study. The researcher made the following observations as implications for this study.

First, the findings of this study were related to the practice of teaching mathematics in a more student-centred approach. The study drew attention to an urgent need for mathematics classroom teaching that will make mathematics more engaging to students and reduces the teacher dominated classroom activities commonly observed in most Nigerian secondary schools. This gives room for more relaxed mathematics classrooms where students are made to be responsible for their own learning. Similarly, the implication of the study also suggested an urgent need to make mathematics classroom practice more engaging, collaborative, participative and all inclusive if mathematics teachers are to improve the conditions of Nigerian mathematics classrooms which the literature reviewed in this study had shown.

Second, this study relates to the concept of Productive Pedagogies which looks at teaching as collaborative as against the individualistic classroom teaching approach commonly held in the Nigerian classroom. Students in such classrooms are perceived as passive listeners as against active participants resulting from the implementation of the Productive Pedagogies framework, and indeed the constructivist perception of students' self-generated knowledge. This study suggested that the participating teachers created opportunities for supportive and inclusive classrooms where students' voices were respected and regarded as part of the ingredients of effective classroom instruction. These experiences were new to both the teachers and students and, therefore, were enjoyed and appreciated.

Third, the implication of this study suggested that creating activities that are challenging, demanding and difficult to help develop the intellectual quality skills of students, through effective substantive conversation and developing problems solving strategies that require higher order thinking, deep knowledge, deep understanding and knowledge as problematic, is important to effective classroom teaching. This helped students develop and construct new knowledge that will improve their intellectual quality skills.

The findings of the study also provided evidence to support mathematics teachers providing opportunities for the development of self-generated knowledge among students using Productive Pedagogies principles. This was evident from the findings of the study where the participating teachers allowed some level of classroom control by the students. The students were responsible for their own learning. According to the study, teachers provided the students with the content of what to learn and the students developed their own approaches to the solution with little or no assistance from the teachers.

Fourth, the implication for this study suggested that making mathematics real and practical is a necessary ingredient for improving students' participation and interest in mathematics. This helps students make real life connections of the mathematics they are learning to the wider world using the improvised material provided by their teachers. Such efforts support students' understanding of mathematics. It also allows students to draw upon their familiar experiences in making sense of the mathematics they are learning. This could also support students' ability to see that the context of mathematics they are learning relates to their real life experiences and uses this knowledge to improve their lives.

Fifth, the study suggested that the new methodology utilised in this research, where secondary school students talked about their teachers' instructions and on the effectiveness of Productive Pedagogies in their classroom engagement was particularly beneficial and advantageous to the researcher, the participating teachers and to the students themselves. The interviews provided opportunities for discussion of views on what quality classroom teaching entails. It also created in students the opportunity to discuss their teachers' effectiveness in the organization of classrooms that listened to student voices. Similarly, this methodology also provided opportunity for the participating teachers to receive feedback from their colleagues on their classroom instruction. Their students' comments also constituted the subject for discussions during reflection meetings with the participating teachers and as a source of scaffolding received by the participating teachers.

The implication for this study also suggested that the new methodology adopted in this study also provided the participating teachers with the opportunity to observe, discuss, and commented on their colleagues' classroom instruction in the community of practice. This was observed to be generally beneficial to the participating teachers who had the opportunity to receive and give support to their colleagues on how quality classroom teaching should be and what are the necessary corrections to be made to achieve better classroom teaching in the future. This was also new to the teachers and hence provided a springboard for teachers' development program.

7.3: Limitations of the Study

There are some limitations that were observed in this study. However, despite these limitations, the researcher endeavoured to make sure the research was successful. These limitations include:

First, the time for this research constituted a major limitation observed in the study. The researcher was only able to use two days for the workshop to introduce the principles and practice of Productive Pedagogies to the participating teachers. This short time compelled the researcher to adopt the scaffolding approach in the training to give the participating teachers further guidance as the research progressed. In an ideal situation, Productive Pedagogies could have been used as a course unit for at least a semester in the participating teachers' class in the University before implementing their understanding in the field. Perhaps due to these limitations, some elements were completely absent during the field practice of the participating teachers, while others were not properly implemented as observed from the findings of this study. Their understanding and application of the framework was limited and perhaps affected during their classroom teaching.

Similarly, the participating teachers were only able to spend ten weeks of teaching and to conduct planning and reflection meetings with the students during Phase 1 of the study. This was not enough for them to implement all the elements of the framework to achieve quality classroom teaching using the Productive Pedagogies framework. If the participating teachers had taught these student for at least a year or for the whole academic session it would have possibly allowed them more time to establish a solid foundation for better implementation of the framework.

Second, to achieve credibility in the interpretation of the research results as a novice researcher was another limitation to this research. This is because it was challenging to keep the researchers' voice hidden behind those of the participating teachers and the focus group students in accordance with the advice from Fine and Weis (1997). In other words, it was not possible to completely disallow the personal views of the researcher on issues discussed during the research from influencing those of the participating teachers and the focus group students, either during personal interactions with these participants, or during reflection meetings, Casual Interviews and focus group discussions.

Similarly, the conditions provided during the research period may have introduced changes or routine activities that might have influenced the actions and inactions of the participants. This is because qualitative research is intended to be conducted in its natural settings. However, these are generally unavoidable in any qualitative research practice.

Finally, there was the lack of previous research with regard to using the Productive Pedagogies framework to reform mathematics classroom practice in Nigerian secondary schools. The implication of this is that the researcher used most references and examples of classrooms in other countries and cultures to reflect what applies to the Nigerian culture and classrooms, as for example Alsharif in Saudi Arabia (Alsharif, 2012) and Tanko in United Arab Emirates (Tanko, 2012). References relating to other classroom settings in the Nigerian classrooms context were also used even though they may have not been used under the same conditions. However, it is believed that such differences might have not been pronounced enough to affect the results of the study.

7.4: Recommendations for Further Research

To the best of the researcher's knowledge, Productive Pedagogies is a new concept in Nigerian classrooms. There are no research studies on teaching mathematics and indeed other subjects found in the literature using the concepts and principles of Productive Pedagogies as a model in Nigerian secondary school classroom contexts. Therefore, the findings of this study could serve as a springboard for further research on Productive Pedagogies in Nigerian secondary schools and indeed in different levels of education. The researcher at this juncture makes the following suggestions and directions for future research that could help advance understanding of mathematics classroom instruction.

First; a replication of a similar study on the effects of introducing Productive Pedagogies in Nigerian secondary school should be carried out. This will help shape, reshape or shed more light on those views expressed by this researcher, the participating teachers, the focus group students and other students and teachers who directly or indirectly participated in this research.

Second, further research should be conducted at both lower and higher levels of education in Nigeria using the Productive Pedagogies framework to diversify the introduction of the framework into the other levels of education in Nigeria. This will help establish credibility in the findings of this study in the Nigerian context. Similarly, it is observed in the literature in this study, that other countries had advanced this type of study in elementary, secondary and tertiary institutions using the principles and practice of Productive Pedagogies. If this is explored in other educational levels in Nigerian, it will also help in the advancement of Productive Pedagogies in Nigerian education system. Similarly, secondary school students participated in this study to discuss their engagement in mathematics classroom teaching. To the best of their abilities, they were able to express themselves on their perceptions on the role of Productive Pedagogies in their classroom engagement. Therefore, it would be interesting to see if the views expressed by these students in this research are shared by the students at other levels of education in Nigeria.

Third, a more longitudinal study should be conducted using the principles of Productive Pedagogies in order to ascertain the long-term benefits of the framework in the Nigerian classroom context. This is important because teachers will have enough time to implement all the dimensions and elements of the framework. It was earlier observed in this study that, because of the limited time available to the researcher and participating teachers, some elements were not properly implemented, while others were completely missing from the implementation and discussions of the participating teachers on the framework. Similarly, conducting a longitudinal study may also reveal that Productive Pedagogies as a framework does not disadvantage students academically, instead it provides them with opportunities to dialogue, collaborate, converse, critique and construct their own knowledge in an effort to achieve quality classroom learning. This will generally help students to be better prepared for their future educational journeys through the constructivist and independent approach to learning as promoted in the Productive Pedagogies framework.

7.5: Summary

This study was set to investigate the effectiveness of introducing Productive Pedagogies into Nigerian secondary schools mathematics classrooms. Specifically, the study investigated the classroom teaching of four mathematics teachers in three secondary schools in Nigerian for 15 weeks (10 weeks in Phase 1 and 5 weeks in Phase 2). The research objectives that guided the study included: investigating the scaffolding needed, the implementation of the framework, the participating teachers' reflections, the focus group students' perceptions, and the challenges encountered introducing the Productive Pedagogies framework to the Nigerian mathematics classroom.

Four participating teachers who were part-time students of a university in the North Eastern Nigeria constituted the sample for the study. These teachers were final year students conducting their final year research project in a community of practice. Their classroom teaching practices were observed through peer observation and by the researcher, there were also three reflection meetings held to discuss and reflect on the practice of these four participating teachers. Six Senior Secondary School 2 students also voluntarily agreed to participate in three focus group discussions on their engagements in the mathematics classrooms created by these participating teachers. The researcher also adopted Casual Interviews with both students and teachers who participated in the research as a means of obtaining data for the study.

The findings of this study as discussed in the sections above suggested that the participating teachers made every effort to demonstrate the concept of Productive Pedagogies in their classroom instruction which increased student-centred learning as against the traditional classroom instruction. The findings also suggested that the participating teachers created classroom climates which helped their students construct their knowledge, discover relationships, solve problems, and collaborate with one another through substantive conversations in their effort to achieved quality classroom instruction. The findings of the study also suggested that the participating teachers made efforts to make their mathematics classroom instruction real and practical to their students through improvisation of locally made instructional aids in order to make their classroom instructions effective, real, and practical. They also used events, activities, real and abstract concepts around their students' immediate environment to help their students relate and link the mathematics concepts which they were learning in the class to the real world around them.

The findings of the study, however, suggested that some of the participating teachers did not properly implement some elements of the Productive Pedagogies framework and others were completely absent from their classroom instruction and from their discussions. Perhaps the reasons for this, as discussed in the study, are as a result of the limited time the researcher had in introducing the Productive Pedagogies framework to the participating teachers. The time for the entire research could also have been the cause of the limitations or challenges the participating teachers faced as described from the findings of the study.

The reflections of the participating teachers and the focus group students, suggested that Productive Pedagogies could be a very effective model that could be used to improve the teacher-student and student-student relationships. This was demonstrated through the friendly classroom climate created by the participating teachers and enjoyed by their students during the research. The result of this increased students engagement, collaborations, interactions, substantive conversations and effective inclusion during mathematics classroom teaching was demonstrated in the findings of this study.

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Every reasonable effort has been made to acknowledge the owner of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

APPENDIX 1
CANDIDACY APPROVAL

Curtin University

Official Communication

Curtin University is a trademark of Curtin University of Technology CRICOS Provider Code WA 00301J, NSW 02637B

ID:	*120276772*
Date:	*Thu 12/05/2011 02:19 PM*
From:	*Science & Engineering Student Services*
To:	*Iliya Joseph Bature*
Subject:	*Confirmed Candidature*

Dear Iliya,

I am pleased to advise that the Faculty Graduate Studies Committee approved your Application for Candidacy.

The candidacy details are as follows:

Thesis Title: Productive Pedagogies for Reforming Mathematics Classroom Practice in Nigerian Universities.

Thesis Committee

Chairperson: Professor David Treagust (Contribution 0%)
Supervisor: Associate Professor Bill Atweh (Contribution 80%)
Associate Supervisor: Doctor Tony Rickards (Contribution 20%)
Candidacy approved: 19th of April 2011.
Under the Higher Degree by Research Rules, the Faculty Graduate Studies Committee must approve any future changes to your candidacy i.e. change of title, change of thesis committee.

***Please note**, where a change of title reflects a changed direction of research, a second Application for Candidacy with a new research proposal must be submitted for approval.*

Regards,

Faculty Graduate Studies Officer | Email: sciengresearch@curtin.edu.au | Telephone: +61 8 9266 7303|Facsimile: +61 8 9266 4606

Copy to Supervisor

Research Enrolment Advice

Curtin
University of Technology

WA CRICOS Provider Code: 00301J
NSW CRICOS Provider Code: 02637B

Your final Commonwealth or personal fee liability is calculated on your enrolment as at census date for the study period in which you are enrolled.
You will be invoiced for your Commonwealth or personal fee liability. Please check the information provided below carefully.

Iliya Joseph Bature
63 Jackson Rd
KARAWARA WA 6152

as at: 13 December 2010
1:14:27PM
ID No.: 14481521

Iliya Joseph Bature
This is how your name will appear on all official documentation including any degree or other award you are granted.
If it is not correct, please contact Student Central or your relevant Student Services Office to have it corrected.

301878 Doctor of Philosophy - Science and Mathematics Education

Location: Bentley Campus
FEC Date: 12/12/2014

Enrolment Status

Research Study Package	Status	Location	Attendance Type	Liability Category
99128 Doctoral Thesis - Science Education	Enrolled	Bentley Campus	Internal	Intl Onshore Fee Paying

Dates and Load Relevant to Year: 2010

From Date	To Date	Period	Proportion of Full-time Load
1/07/2010	12/12/2010	2	0.000
13/12/2010	31/12/2010	2	1.000

<u>Funding EFTSL Consumed (FEC) date</u>
The FEC date signifies the end of the time limit for enrolment in your degree, as set down by the Department of Education, Employment and Workplace Relations (DEEWR). Your enrolment is continuous up to your FEC date (except for approved periods of Leave of Absence), and cannot be extended. If you have not submitted your thesis by the FEC date, you will be considered 'overtime' by both the University and DEEWR, and this may have fee implications.

<u>Note regarding proportion of full-time load</u>
A value of 1.00 is the equivalent of full-time enrolment in the thesis for the period shown.

A value of 0 indicates there is enrolment in the thesis, but the load of the thesis has been set to zero for the period shown. This may occur where Leave of Absence has been approved, or where coursework is being undertaken, or where there has been a change in status such as "Thesis Under Examination".

<u>Note regarding deadlines</u>
Higher Degree by Research students should note the census date for Enrolment Period (EP) 1 is 31 March and for EP 2 is 31 August. Students should contact Faculty Graduate Studies Officers if there is a need to change enrolment after census date.

APPENDIX 2
RESEARCH STUDENTS PROFILE

Research Student Profile — **Curtin University of Technology**

Student ID: 14481521 **Name:** Iliya Joseph Bature **Profile Printed:** 13 December 2010

Contact Address: 63 Jackson Rd
KARAWARA WA 6152

Phone: 08038808060 (H)
0414269348 (W)
08038808060 (M)
(FAX)

Date of Birth: 13 January 1965 **e-mail:**
i.bature@student.curtin.edu.au
student provided email: ijbature@yahoo.com

Course: 301878 v. 2 Doctor of Philosophy - Science and Mathematics Education **Owning Organisation:** 1028

Course Status: ADM **Course Start Date:** 27/09/2010 **Academic Status:** Good Standing

Max Funded EFTSU: 4.00 **Prior EFTSU This Uni:** 0.000 **Prior EFTSU Other Uni:** 0.00

Liability Category Description (Course): Intl Onshore Fee Paying

Student Status: 310 **Date set:** 13-December-2010

Fee-paying overseas students. A fee-paying overseas student not sponsored under a foreign aid program, and including students with awards: IPRS; SOPF; Australian-European Awards Program; and the Commonwealth Scholarship and Fellowship Plan

Sponsor: (6739) A.T.B. University,Nigeria **Start Date:** 25/10/2010 **End Date:** 13/12/2013 **Percentage:** 100.00
Sponsored Spk: (301878-Ver 2)Doctor of Philosophy - Science and Mathematics Education

ENROLMENT IN THESIS - STUDY RATES

99128 v. 3.00 Doctoral Thesis - Science Education **Attempt No:** 1.00 **Status:** ENR

Thesis Title: Effect of Metacognitive Instructional Strategy on Students Achievement and Attitude Towards Mathematics' Worded Problems

Year	EP	Start Date	End Date	Study Rate	
2010	2	01/07/2010	12/12/2010	0.00	
2010	2	13/12/2010	31/12/2010	1.00	
2011	1	01/01/2011	30/06/2011	1.00	
2011	2	01/07/2011	31/12/2011	1.00	
2012	1	01/01/2012	30/06/2012	1.00	
2012	2	01/07/2012	31/12/2012	1.00	
2013	1	01/01/2013	30/06/2013	1.00	
2013	2	01/07/2013	31/12/2013	1.00	
2014	1	01/01/2014	30/06/2014	1.00	
2014	2	01/07/2014	11/12/2014	1.00	
2014	2	12/12/2014	31/12/2014	1.00	OT

COURSEWORK HISTORY FOR THIS COURSE

Year	Study Period	Spk Cd	Vers.	Spk Title	Credits	Status

LEAVE OF ABSENCE

Leave No.	From Date	To Date

Explanation of codes: ADM - Admitted LOA - Leave of absence ENR - Enrolled PLN - Planned UX - Under examination
PASS - Passed CONV - Converted AWOL - Absent Without Leave EP - Enrolment Period RTS - Research Training Scheme
OT -Overtime FEC "Funded EFTSU Consumed" date. This date marks the end of the normal course duration expected for the degree.
Students who have been permitted to enrol beyond the FEC date are regarded as overtime and as such may be charged tuition fees.

(CuS1AE003d) *1:18:19PM* *Page 1 of 2*

APPENDIX 3
INFORMATION'S FOR RESEARCH PARTICIPANTS

1: Information for Participating Teachers

Curtin University of Technology
Science and Mathematics Education Centre

22nd March, 2011

Sir,

Participating Teachers Information Sheet

My name is **Iliya Joseph Bature** *currently working on my Doctor of Philosophy in Mathematics Education at Science and Mathematics Education Centre, Curtin University of Technology, Bentley, Perth, Western Australia, Australia.*

Purpose of Research: *I am working on a research topic: "***Productive Pedagogies for** ***Reforming Secondary School Mathematics Classroom in Nigerian"***

Your Role will include:

I am seeking your permission to use you as a subject for my research, and your role in the research will be that

1. *That you will be conducting your own research, working on Productive Pedagogies while I served as a facilitator monitoring and guiding you on how the research will be conducted, and the data generated will be yours for your undergraduate project*
2. *You will be working with three other teachers, on your own research topic for a period of 15 weeks teaching Mathematics your class using Productive Pedagogies framework.*
3. *That you will be willing to participate in the workshop sessions on Productive pedagogies, and on strategies for data collection, for two days.*
4. *That you will be willing to be a subject to be observed by other participating teachers, who are working with you on similar topics, hence will use you as their subject during the research.*
5. *That you will also be willing to observed other researchers using them as your participants during the research as a means of obtaining data from them. This will involve observations, and reflections meetings.*
6. *Since the research is in a community of practice, there will reflection meetings, with other participating teachers, observations, and report writing, on the introduction of Productive Pedagogies framework in Nigerian mathematics classroom; hence you will be willing to make yourself available for these meetings.*

Consent to Participate: *Your participation in this research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. I* *shall be grateful to receive your response on your willingness to participate in writing through the email address below, so that we can make a final decision on those who will be participating. This should include a brief resume and your research experience. If you don't have any, you can still indicate your interest as this is a law in Australian Universities.*

Confidentiality: *The information you provided in this research will be kept separate from your personal details, and only myself and my supervisor will have access to them. The focus groups discussions transcript will not have your name or any other identifying information on it and in adherence to Curtin University policy, transcribed information will be kept in a locked cabinet for at least five years, before a decision is taken as to whether it should be destroyed.*

Further Information: *This research has been reviewed and given approval by Curtin University Human Research Ethics Committee.*

If you would like further information about the study, please feel free to contact me.

Iliya Joseph Bature
Science and Mathematics Education Centre, Curtin University
P O Box U1987
Perth WA 6845
Email: i.bature@curtin.edu.au.
Phone: +61469012411
Alternatively, you can contact my supervisor

Associate Professor Bill Atweh
Science and Mathematics Education Centre, Curtin University
P O Box U1987
Perth WA 6845
Phone: +61 (0)8 9266 7073
Fax: +61 (0)8 9266 2503
Email: b.atweh@curtin.edu.au

Thank you very much for your involvement in this research. Your participation is greatly appreciated.

Iliya Joseph Bature ***(14481521)***

2: Information for Principals

Curtin University
Science and Mathematics Education Centre

22^{nd} August 2011

The Principals
The Devine International School, Bauchi.
Anglican Junior Seminary, Kafanchan
Akiluwa Secondary School, Fakkos-Bokkos
Sir,

Permission to Conduct Research in your School

My name is **Iliya Joseph Bature** *I am currently completing a research for my Doctor of Philosophy (PhD) in Mathematics Education at Science and Mathematics Education Centre, Curtin University, Bentley Perth, Western Australia*

Purpose of Research: *I am working on the research topic:* ***Productive Pedagogies for reforming secondary School Mathematics Classroom Practices in Nigerian.***

Benefits:

1. *This research will afford your school the opportunity to be the starting/reference point for the introduction of Productive Pedagogies in Nigeria as the University of Queensland had been the reference point and is refers to as the Productive Pedagogies university in Australia and the world.*
2. *Productive Pedagogies is a new area in Nigeria and indeed in every part of the world as it only come into the lifeline of educational practice at the University of Queensland in 2001. Learning about this will give your school the opportunity to developed positive attitude towards mathematics classroom instructions as this had been the problem to most mathematics classrooms in Nigeria.*
3. *Mathematics Education teaching learning process had been criticize as being not well taught or learnt, by implication the heart cry of parents, teachers, government and the society at large. This has resulted to students' low grades score every year at all levels of education in Nigeria. Hence if this is well implemented, it is believed that it will solve the problem of mathematics being a monster among students.*

Your Role: *I am seeking your permission to conduct research in your school sir, and also seeking your indulgence in the following areas of support.*

7. *Asking for your support morally, psychologically, physically, emotionally and financially, to make this research a success.*
8. *Asking for your mathematics that are willing to participate in the workshop to avail themselves with this opportunity of learning new techniques to classroom instruction using productive pedagogies framework.*

9. *Asking for six senior secondary schools 2 students to participation in a Focus Group discussion about their perception on the reform on mathematics classroom practice using productive pedagogies.*
10. *Asking for Accommodation (One room in the campus), an office space with a desk and chair for the purpose of the research, since the researcher will have to stay in the campus for the period of the research which is one semester of about 16 to 18 weeks.*
11. *However, I should also mention here that the research will in no wise* ***interfere*** *with official duties during the term as the participating teachers will follow the terms' school timetable to teach your students.*

Consent to Participate: *The students and your involvement in this research is entirely voluntary. You have the right to withdraw yourself and or any of your participants from this research at any stage without it affecting your rights or my responsibilities. I will be very grateful if you can consent to this in writing as this is one of the criteria for all researchers in Australian Universities.*

Confidentiality: *The information you provided will be kept separate from your personal details, and only myself and my supervisor will have access to the information. The focus groups discussions transcript will not have the names or any other identifying information on it and in adherence to Curtin University policy, transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.*

Further Information: *This research has been reviewed and given approval by Curtin University Human Research Ethics Committee. If you would like further information about the study, please feel free to contact me.*

Iliya Joseph Bature Science and Mathematics Education Centre, Curtin University P O Box U1987 Perth WA 6845 Email: i.bature@curtin.edu.au. Phone: +61469012411 Alternatively, you can contact my supervisor

Assoc. Professor Bill Atweh Science and Mathematics Education Centre Curtin University of Technology P O Box U1987 Perth WA 6845 Phone: +61 (0)8 9266 7073 Fax: +61 (0)8 9266 2503 Email: b.atweh@curtin.edu.au

Thank you very much for your involvement in this research. Your participation is greatly appreciated.

Iliya Joseph Bature (14481521)

3: Information for Students

Curtin University of Technology
Science and Mathematics Education Centre

19th April 2011

Dear Student

Focus Group Students Information Sheet

My name is Iliya Joseph Bature currently completing a research for my Doctor of Philosophy in Mathematics Education at Science and Mathematics Education Centre, Curtin University of Technology, Bentley, Perth, Western Australia, Australia.

Purpose of Research: *I am working on a research topic: Productive Pedagogies for Reforming Mathematics Classroom Practices in Nigerian Colleges of Education through Participatory Action Research.*

Your Role: *I am seeking your permission to use you as a subject for my research, and your will be that you will be willing to discuss with me during a focus group discussion and also submit yourself for interview whenever I come to your class or you are invited for that purpose.*

Consent to Participate: *Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. If you are interested to participate in this research, you indicate your willingness in writing through the email below.*

Confidentiality: *The information you provided will be kept separate from your personal details, and only myself and my supervisor will have access to the information. The focus groups discussions transcript will not have your name or any other identifying information on it and in adherence to Curtin University policy, transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.*

Further Information: *This research has been reviewed and given approval by Curtin University Human Research Ethics Committee. If you would like further information about the study, please feel free to contact me.*

Iliya Joseph Bature *Science and Mathematics*
Education Centre
Curtin University
P O Box U1987
Perth WA 6845 *Email: i.bature@curtin.edu.au.*
Phone: +61469012411

Alternatively, you can contact my supervisor

Assoc. Professor Bill Atweh
Science and Mathematics Education Centre
Curtin University of Technology
P O Box U1987 Perth WA 6845
Phone: +61 (0)8 9266 7073
Fax: +61 (0)8 9266 2503
Email: b.atweh@curtin.edu.au ***Thank you very much for your involvement in this research.Your participation is greatly appreciated.***

Iliya Joseph Bature (14481521)

APPENDIX 4
PRODUCTIVE PEDAGOGIES
CLASSROOM OBSERVATION MANUAL

This booklet has been adapted from the Queensland School Reform Longitudinal Study (QSRLS) commissioned by Education Queensland

School Reform Longitudinal Study
Classroom Observation Coding Manual

Scoring instructions

Consider the explanations given for each dimension, using the descriptions of the scores from 1-5 on each to constitute the minimum criteria for each. Where difficulty is encountered in selecting between two scores, consider whether the minimum conditions of the higher score have been met. If these conditions have not been met, the lower score should be used. In determining scores for each dimension, the observer should only consider the evidence seen during the specific period.

CONTENTS

Intellectual Quality
Knowledge as Problematic
Higher Order Thinking
Depth of Knowledge
Depth of Students' Understanding
Substantive Conversation
Metalanguage

Connectedness
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Knowledge Integration
Background Knowledge
Problem Based Curriculum

Supportive Classroom Environment
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Social Support
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Student Self-Regulation

Recognition of Difference
Cultural Knowledges
Active Citizenship
Narrative
Group Identities in Learning Communities
Representative Participation

KNOWLEDGE AS PROBLEMATIC

Are students critiquing and second-guessing texts, ideas and knowledge?

Presenting knowledge as problematic involves an understanding of knowledge not as a fixed body of information, but rather as being constructed, and hence subject to political, social and cultural influences and implications. Multiple, contrasting, and potentially conflicting forms of knowledge are represented.

Knowledge as given sees the subject content within the class represented as facts, a body of truth to be acquired by students. The transmission of the information may vary, but is based on the concept of knowledge as being static and able to be handled as property, perhaps in the form of tables, charts, handouts, texts, and comprehension activities.

No knowledge problematic 1 . . . 2 . . . 3 . . . 4 . . . 5 All knowledge problematic

1. *No knowledge as problematic. All knowledge is presented in an uncritical fashion.*
2. *Some knowledge seen as problematic - but interpretations linked/reducible to given body of facts.*
3. *Approximately half knowledge seen as problematic. Multiple interpretations recognised as variations on a stable theme.*
4. *Explicit valuation of multiple interpretations and constructions of information, presented as having equal status, and being equally accommodated and accepted by others.*
5. *All knowledge as problematic. Knowledge is seen as socially constructed, with conflicting implications and social functions producing resolution and/or conflict.*

Example:

As an introductory lesson to a topic about the environment, a Year 8 Social Science teacher drew a long horizontal line across the blackboard and wrote 'very concerned' at one end and 'not concerned' at the other end. She asked students to place a mark on the line representing their degree of concern about the environment.

This required that the students make a 'low-key' public statement about their position and then justify it in writing by answering the question: 'Why I chose my position'. The teacher made a number of statements that could be interpreted as supporting multiple positions, thus reinforcing that there was no one correct position.

It was clear from the way that this piece was managed that the teacher anticipated divergent and potentially conflicting views to surface during the activity. She skilfully and continually kept opening the discussion up by reinforcing the complexity of the issues and the need to consider multiple viewpoints and experiences.

HIGHER ORDER THINKING

Are students using higher order thinking operations within a critical framework?

Higher Order Thinking requires students to manipulate information and ideas in ways that transform their meaning and implications. This transformation occurs when students combine facts and ideas in order to synthesize, generalize, explain, hypothesize or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allows students to solve problems and discover new (for them) meanings and understandings. When students engage in the construction of knowledge, an element of uncertainty is introduced into the instructional process and makes instructional outcomes not always predictable; i.e., the teacher is not certain what will be produced by students. In helping students become producers of knowledge, the teacher's main instructional task is to create activities or environments that allow them opportunities to engage in higher order thinking.

Lower Order Thinking occurs when students are asked to receive or recite factual information or to employ rules and algorithms through repetitive routines. Students are given pre-specified knowledge ranging from simple facts and information to more complex concepts. Such knowledge is conveyed to students through a reading, work sheet, lecture or other direct instructional medium. The instructional process is to simply transmit knowledge or to practice procedural routines. Students are in a similar role when they are reciting previously acquired knowledge; i.e., responding to test-type questions that require recall of pre-specified knowledge. More complex activities still may involve reproducing knowledge when students only need to follow pre-specified steps and routines or employ algorithms in a rote fashion.

Lower order thinking 1 . . . 2 . . . 3 . . . 4 . . . 5 higher order thinking

1. *Students are engaged only in lower order thinking; i.e., they either receive, or recite, or participate in routine practice and in no activities during the lesson do students go beyond simple reproduction.*
2. *Students are primarily engaged in lower order thinking, but at some point they perform higher order thinking as a minor diversion within the lesson.*
3. *Students are primarily engaged in routine lower order thinking a good share of the lesson. There is at least one significant question or activity in which some students perform some higher order thinking.*
4. *Students are engaged in at least one major activity during the lesson in which they perform higher order thinking, and this activity occupies a substantial portion of the lesson and many students are engaged in this portion of the lesson.*
5. *Almost all students, almost all of the time, are engaged in higher order thinking.*

Example:

The topic of a Stage 1 Maths lesson was classification and grouping generally and more specifically, set theory. The teacher brought in a range of diverse objects. Students, in groups, had to categorise them according to criteria which the students themselves determined in their groups.

At the end of that part of the lesson, the groups rotated around the classroom and in groups suggested the basis of classification. The teacher then gave hoola-hoops to each group and asked them to place them in an overlapping set fashion. Instructions were given as to what was desired, with the request that pieces in the overlapping or intersecting set had to have characteristics in common with each of the hoops. The groups did this and again rotated and discussed the basis of the classification.

The basis of the classification was determined by the students and could be determined for a variety of reasons, for example, they were all yellow, or all dirty, all cubes etc. Students simply had to articulate reasons and justify their classifications. The lesson concluded with the teacher making comments regarding the use of symbolic representations in Maths.

DEPTH OF KNOWLEDGE

Does the lesson cover operational fields in any depth, detail or level of specificity?

Knowledge is deep or thick when it concerns the central ideas of a topic or discipline and because such knowledge is judged to be crucial to a topic or discipline. Knowledge is deep when relatively complex relations are established to central concepts.

Knowledge is shallow, thin or superficial when it is not connected with significant concepts or central ideas of a topic or discipline, and it is dealt with only in an algorithmic or procedural fashion. Knowledge is also shallow when important, central ideas have been trivialized by the teacher or students, or when it is presented as non-problematic. This superficiality can be due, in part, to instructional strategies such as when teachers cover large quantities of fragmented ideas and bits of information that are unconnected to other knowledge.

Knowledge is shallow 1...2...3...4...5 Knowledge is deep

1. *Almost all of the lesson's content knowledge is very thin because it does not deal with significant topics or ideas.*
2. *Knowledge remains superficial, but some key complex concepts and ideas are mentioned or covered by the teacher or students on a superficial or trivialized level.*
3. *Knowledge is treated unevenly during instruction; i.e., deep knowledge of something is countered by superficial understanding of other knowledge. At least one significant idea may be presented in depth, but in general the focus is not sustained.*
4. *Most of the presented knowledge is relatively deep because either the teacher or the students provide information, arguments or reasoning that demonstrates the complexity of an important idea. Sustained focus on central content is occasionally interrupted by thin knowledge coverage.*
5. *Knowledge is very deep because almost all knowledge presented in the lesson sustains focus on a significant topic, and does so either through a complex structure or by demonstrating the problematic nature of information and/or ideas.*

Example:

Year 11 Multi-strand Science students were nearing the completion of an extensive study of the ecosystem of the town's river. Previous work included a substantial amount of in-class and fieldwork activities, such as using classification systems, water quality monitoring and studying impact of flood and industry along the river, which sought to make the students 'experts' on the ecosystem of their local river.

The students were asked to apply this deep knowledge to the task of creating a creature adapted to the conditions of the river ecosystem. The creation of this creature was dependent upon the students having a thorough knowledge of the topic.

DEPTH OF STUDENTS' UNDERSTANDING

Does the work and response of the students provide evidence of depth of understanding of concepts or ideas?

For students, knowledge is deep when they develop relatively complex understandings of these central concepts. Instead of being able to recite only fragmented pieces of information, students develop relatively systematic, integrated or holistic understandings. Mastery is demonstrated by their success in producing new knowledge by discovering relationships, solving problems, constructing explanations, and drawing conclusions.

Students' understanding of important concepts or issues is taken to be superficial when ideas are presented by students in a way which demonstrates that they only have a surface acquaintance with the meaning. Evidence of shallow understanding by students exists when they do not or cannot use knowledge to make clear distinctions, arguments, solve problems and develop more complex understandings of other related phenomena.

Understanding is shallow 1...2...3...4...5 Understanding is deep

1. *Almost all of the students demonstrated understanding involving the coverage of simple information which they are to remember.*
2. *While some key concepts and ideas are mentioned or covered by the students, students demonstrate only a superficial acquaintance or trivialized understanding of these complex ideas.*
3. *Students' deep understanding is uneven. Deep understanding of something, by some students, is countered by superficial understanding of other knowledge (by either the same or other students). At least one significant idea may be understood in depth, but in general the focus is not sustained.*
4. *Most students' understanding is relatively deep because the students provide information, arguments or reasoning that demonstrates the complexity of an important idea for a substantial portion of the lesson. in this portion of the lesson, students do at least one of the following: sustain a focus on a significant topic for a period of time; demonstrate their understanding of the problematic nature of information and/or ideas; demonstrate understanding by arriving at a reasoned, supported conclusion; or, explain how they solved a relatively complex problem.*
5. *Almost all students do at least one of the following: sustain a focus on a significant topic; or demonstrate their understanding of the problematic nature of information and/or ideas; or demonstrate complex understanding by arriving at a reasoned, supported conclusion; or explain how they solved a complex problem. in general, students' reasoning, explanations and arguments demonstrate fullness and complexity of understanding.*

Example:

A year 12 art class worked collaboratively on a submission to design a 3-D installation for a public space with a youth theme.

The collaborative nature of the piece required extended dialogue between students and the teacher to develop shared ideas, concepts, themes and design elements. Because the installation was planned for a public space, local government officers were also consulted. The students demonstrated complex understandings of each stage of the project: the specifications of the design brief, the time frame of the project, the sourcing of materials and the preparation of the application.

Their final proposal was supported by reasoned and creative explanations of its aesthetic and functional appeal.

In the class we observed there was very little teacher direction. Students were clearly engaged in the project in ways that demonstrated their complete understanding of what was expected of them. They were able to provide an insightful artistic explanation of their work.

SUBSTANTIVE CONVERSATION

Does classroom talk lead to sustained conversational dialogue between students, and between teachers and students to create or negotiate understanding of subject matter?

In classes with substantive conversation there is considerable teacher-students and student-student interaction about the ideas of a substantive topic; the interaction is reciprocal, and it promotes coherent shared understanding. This scale assesses the extent of talking to learn and to understand in the classroom.

Substantive Conversations includes the features below:

1. **Intellectual Substance:** *The talk is about subject matter in the discipline and encourages critical reasoning such as making distinctions, applying ideas, forming generalizations, raising questions. It moves beyond just the recounting of experiences, facts, definitions, or procedures (e.g., technical language, analytical distinctions and categories being made, levels or differentiations between types and arguments stated, grounds for disagreement stated).*
2. **Dialogue***: The conversation involves sharing of ideas and is not completely scripted or controlled by one party (as in teacher-led recitation). Sharing is best illustrated when participants provide extended statements, direct their comments, questions and statements directly to others, redirect and select next speakers.*
3. **Logical Extension and Synthesis***: The dialogue builds coherently on participants' ideas to promote improved collective understanding of a theme or topic. In short, substantive conversation resembles the kind of sustained exploration of content characteristic of a good seminar where student contributions lead to shared understandings (e.g., teachers and students may make principled topic shifts, may use linking-words, make explicit references to previous comments, and may summarise).*
4. ***A Sustained Exchange*** *extends beyond a routine IRE. This can occur between teacher and students or student and student and involves several consecutive interchanges. Dialogue consists of a sustained and topically related series of linked exchanges between speakers.*

In classes where there is little or no substantive conversation, teacher-student interaction typically consists of a lecture with recitation where the teacher deviates very little from delivering information and routine questions; students typically give very short answers. Discussion here may follow the typical IRE (initiate/response/evaluate) pattern: with low level recall/fact based questions, short utterance or single word responses, and further simple questions and/or teacher evaluation statements (e.g.,"yes, good"). This is an extremely routine, teacher-centred pattern, that amounts to a "fill in the blank," or "guess what's in the teacher's head" format.

No 'sub-con' 1. . . 2 . . . . 3 . . . . 4 . . . . 5 Sustained 'sub-con'

1. *Virtually no features of substantive conversation occur during the lesson. Lesson consists principally of either a sustained teacher monologue/lecture and/or a repeated IRE sequence with little variation, or conversation which is not substantive.*
2. *Features B (DIALOGUE) and/or C (LOGICAL EXTENSION & SYNTHESIS) occur briefly and involve at least ONE SUSTAINED EXCHANGE.*
3. *Features B (DIALOGUE) and/or C (LOGICAL EXTENSION & SYNTHESIS) occur and involve TWO OR MORE SUSTAINED EXCHANGES.*
4. *All features of substantive conversation occur, with sustained exchanges over almost ONE HALF OF THE LESSON, with both teachers and students scaffolding the conversation.*
5. *All features of substantive conversation occur in an ongoing and sustained fashion, extending across almost ALL OF THE LESSON, with both teachers and students scaffolding the conversation.*

Example:

A Stage 3 class had been examining positive and negative experiences of different cultural groups in the community through interviewing family members, reading newspapers, and watching news and current affairs programs.

The class was divided into small groups and each group was given an example of a negative experience and students were asked to suggest possible causes for that experience. Each group reported to the class and a table of possible causes of racism, prejudice and discrimination was compiled.

The students then discussed ways in which prejudice and discrimination could be addressed and a class code of ethics was developed.

METALANGUAGE

Are aspects of language, grammar and technical vocabulary being foregrounded?

High metalanguage instruction has high levels of talk about talk and writing, about how written and spoken texts work, about specific technical vocabulary and words (vocabulary), about how sentences work or don't work (syntax/grammar), about meaning structures and text structures (semantics/genre), about issues how discourses and ideologies work in speech and writing. Teachers tend to do a good deal of pulling back from activities, assignments, readings, lessons, and fore-grounding particular words, sentences, text features, discourses, etc.

Low metalanguage instruction has little explicit talk about talk and writing, about how written and spoken texts work, about their features, characteristics, patterns, genres and discourses. There is an emphasis on simply doing text-based activities, without any pulling back and talking about curriculum and evaluation of texts.

No meta-language 1 . . . 2 . . . 3 . . . 4 . . . 5 High meta-language

Example:

1. **Low Meta-language:** *the teacher proceeds through the lesson, without stopping and commenting on his/her own or students' use of language.*
2. **Some Meta-language***: the teacher proceeds through the lesson, stopping to make value judgements or commentary on language, but without providing any technical terminology, or constructive assistance and clarification.*
3. **Initial or periodic use of Meta-language:** *at the beginning of the lesson, or at some key juncture, the teacher stops and explains or gives a mini-lesson on some aspect of language, e.g., vocabulary, punctuation, grammar, genre.*
4. **Occasional use of Meta-language***: the teacher stops when students are having visible difficulty with aspects of language, providing direct assistance in grammar, vocabulary, genre, discourses.*
5. **Consistent Use of Meta-Language***: the teacher provides ongoing and frequent commentary on language use, perhaps using jokes, puns, and ironic comments on her/his own or students' language, points out how differing sentences, text-types, and discourses actually work, compares and contrasts them, and shows how language can be used to constitute texts, knowledge and power.*

A year 11 English class was being introduced to the concept of 'discourse'. The teacher asked the students to examine how medical, legal and mechanical languages operate within particular contexts to construct speakers, listeners and subjects. The students gave some concrete examples of these and described how power operates in each situation and is closely aligned with knowledge.

By reversing the speaker and the listener, students were able to consider alternative discourses and to examine how power relations can be disrupted. There was consistent use of metalanguage throughout as the teacher and students examined how discourses constitute texts, knowledge and power.

Connectedness

CONNECTEDNESS TO THE WORLD BEYOND THE CLASSROOM

Is the lesson, activity, or piece connected to competencies or concerns beyond the classroom?

Connectedness describes the extent to which the lesson has value and meaning beyond the instructional context, making a connection to the larger social context within which students live.

Two areas in which student work can exhibit some degree of connectedness are: (a) a real world public problem; i.e., students confront an actual contemporary issue or problem, such as applying statistical analysis in preparing a report to the City Council on the homeless; (b) Students' personal experiences; i.e., the lesson focuses directly or builds upon students' actual experiences or situations. A high level of connectedness can be achieved when the lesson entails one or both of these. In a low connectedness lesson with little or no value beyond the classroom, activities are deemed important for success only in school (now or later), but for no other aspects of life. Student work has no impact on others and serves only to certify their level of competence or compliance with the norms and routines of formal schooling.

See table below

Example

A Year 8 English class was provided with the opportunity to conduct an independent unit. The only requirement was that students had to provide a written product and had to present their project to the class.

The criteria for the unit were decided in conjunction with the students. Some of the topics which were covered by students in this class included 'How to do a PowerPoint presentation', 'How to maintain a bicycle', 'How to do sign language', 'How to take good photographs' and 'How to do Japanese cooking'.

In each case the students saw the topics as having value outside of the class. Indeed there was some suggestion, for example, that the students learning how to do PowerPoint presentations would be able to in-service some of the staff. The students learning sign language articulated a number of uses to which they wanted to put their new found skills. The two students who were creating a manual on how to maintain a bicycle were disc

No connection 1 . . . 2 . . . 3 . . . 4 . . . 5 Connected

1. *Lesson topic and activities have no clear connection to anything beyond itself; the teacher offers no justification beyond the need to perform well in class.*
2. *Students encounter a topic, problem or issue that the teacher tries to connect to students' experiences or to contemporary public situations; i.e., the teacher informs students that there is potential value in the knowledge being studied because it relates to the world beyond the classroom. For example, students are told that understanding Middle East history is important for politicians trying to bring peace to the region; however, the connection is weak and there is no evidence that students make the connection.*
3. *Students study a topic, problem or issue that the teacher succeeds in connecting to students' actual experiences or to a contemporary public situation. Students recognize some connection between classroom knowledge and situations outside the classroom, but they do not explore the implications of these connections which remain abstract or hypothetical. There is no effort to actually influence a larger audience.*
4. *Students study or work on a topic, problem or issue that the teacher and students see as connected to their personal experiences or actual contemporary public situations. Students recognize the connection between classroom knowledge and situations outside the classroom. They explore these connections in ways that create personal meaning and significance for the knowledge. However, there is no effort to use the knowledge in ways that go beyond the classroom to actually influence a larger audience.*
5. *Students study or work on a topic, problem or issue that the teacher and students see as connected to their personal experiences or actual contemporary public situations. Students recognize the connection between classroom knowledge and situations outside the classroom. They explore these connections in ways that create personal meaning and significance for the knowledge. This meaning and significance is strong enough to lead students to become involved in an effort to affect or influence a larger audience beyond their classroom in one of the following ways: by communicating knowledge to others (including within the school), advocating solutions to social problems, providing assistance to people, creating performances or products with utilitarian or aesthetic value.*

Connectedness

KNOWLEDGE INTEGRATION

Does the lesson integrate a range of subject areas?

Integrated school knowledge is identifiable when either: a) explicit attempts are made to connect two or more sets of subject area knowledge, or b) when no subject area boundaries are readily seen. Themes or problems which either require knowledge from multiple areas, or which have no clear subject areas basis in the first place, are indicators of curricula which integrates school subject knowledge.

Non-integrated school knowledge is typically segregated or divided in such a way that specific set of knowledge and skills are (relatively) unique and discrete to each specified school subject area. Segregated knowledge is identified by clear boundaries between subject areas. Connections between knowledge in different segregated subject areas are less and less clear the stronger the dividing knowledge boundary. In the extreme, such boundaries prevent any inter-relation of different subject areas.

Knowledge segregated 1 . . . 2 . . . 3 . . . 4 . . . 5 Knowledge integrated

1. *All knowledge strictly restricted to that explicitly defined within a single school subject area. No intrusion of other contents permitted.*
2. *Knowledge mostly restricted to that of a specific subject area, with minor intrusions limited to connections with one other (separate) discipline.*
3. *Knowledge from multiple subject areas connected or related together, but still treated as separate and distinct subjects.*
4. *Near complete integration of multiple subject areas, however some minor inclusion of knowledge that is still treated as unique to a subject area.*
5. *Complete integration of subject area knowledge to the degree that subject area boundaries are not recognisable.*

Example:

Growing enrolments at a high school necessitated increasing the number of houses by two for various inter-house sporting events. To accommodate this change, two extra lanes had to be marked on the running track in time for the school athletics carnival. This prompted a group of year 8 teachers from different disciplines to work together on an integrated unit with the same group of students.

A PE teacher worked with the students to design the new track and athletics field so that it would accommodate the extra competitors. Extra areas had to be allocated for the new house groups, for more marshalling space and for specialized events such as discus and long jump. A Maths teacher worked with her class to determine the actual lengths of the new tracks and the position of the starting blocks for events over various distances. An English teacher worked with his class to draw up programs, advertising material, results lists and signage. A computer studies teacher worked with her class to construct a web site for the carnival and there were continual updates made to this web site. Thus integration in this example occurred around a common topic with subject boundaries remaining intact.

Connectedness

BACKGROUND KNOWLEDGE

Are links with students' background knowledge made explicit?

High connection lessons provide students with opportunities to make connections between their linguistic, cultural, world knowledge and experience and the topics, skills, competencies at hand. Background knowledge may include community knowledge, local knowledge, personal experience, media and popular culture sources.

Low connection lessons introduce new content, skills and competencies without any direct or explicit opportunities to explore what prior knowledge students have of the topic, and without any attempts to provide relevant or key background knowledge that might enhance students' comprehension and understanding of the 'new'.

Low background 1… 2 … 3… 4 …5 High background knowledge links

1. *No reference is made to background knowledge: students' community and cultural knowledge or school knowledge covered in previous studies, other subjects and lessons.*
2. *Students' background knowledge and experience are mentioned or solicited as a motivational technique, but are trivial and not connected to the lesson.*
3. *Initial reference or solicitation is made by the teacher to background knowledge and experience. At least some connection to out-of-school background knowledge.*
4. *Periodic reference or solicitation of background knowledge is made by the teacher. At least some connection to out-of-school background knowledge.*
5. *Students' background knowledge and experiences are consistently incorporated into the lesson, with the lesson shunting back and forth between known material and new material. At least some connection to out-of-school background knowledge.*

Example:

In a year 6 Social Studies class, the children worked in small groups over a number of lessons to design a theme park. This topic was closely connected to the students' world beyond the classroom because the school is located close to a number of major theme parks.

As well as having visited these parks, some of the children knew park employees and the parks were significant in the community's psyche. Along with designing themes, rides and attractions, the children were also required to consider a range of other issues such as profit margins, marketing, integration with other local industries and services, facilities for people with special needs, personnel issues and pricing. The groups gave regular reports to the class and were required to respond to questions posed by the teacher and other students.

A feedback cycle of researching, developing and presenting the theme park designs was well established in the class when this observation was made. A local theme park manager had also been invited to a final presentation of the proposals and to comment on each design.

PROBLEM-BASED CURRICULUM

Is there a focus on identifying and solving intellectual and/or real-world problems?

A problem-based curriculum is identified by lessons in which students are presented with a specific practical, real, or hypothetical problem (or set of problems) to solve.

Problems are defined as having no specified correct solution, requiring knowledge construction on the part of the students, and requiring sustained attention beyond a single lesson.

No problems 1 . . . 2 . . . 3 . . . 4 . . . 5 fully problem based

1. *No problems are presented during the lesson.*
2. *Some minor and small problems (no correct solution) are posed to the students but they require little knowledge construction by students.*
3. *Some minor or small problems are posed to the students requiring substantial knowledge construction/creativity from students.*
4. *A large problem is posed requiring engagement by students throughout a single lesson.*
5. *A large problem has been set requiring engagement by students over a number of lessons.*

Example:

A year 8 Health and Physical Education teacher was working on a unit with a Year 8 class about building a raft. Teacher directed discussion ensued about what skills the students would need to build the raft and what outcomes they wanted from the exercise. This was discussed and negotiated.

The students suggested that if they were going to build a raft, they needed to learn how to effectively work in groups. In response to that the teacher had the students play a game in the gym where students were allowed to throw balls in all directions with the aim of the game being to keep the balls in perpetual motion. There was frenetic movement of balls around the class. The teacher stopped the game and asked how it could be modified to work more effectively. There was extensive discussion about rules. Much of this discussion was extended to take in questions of rules in society – questions of who created them, why, were they able to be negotiated, did everyone have the same opportunity to create the rules and so on.

The game continued under different sets of rules. Students were able to construct rules, argue why they were appropriate and look at their effects. This one lesson was not treated as an isolated incident but as focusing on the development of one skill needed in order to solve the larger problem. A number of other interesting lessons were conducted by this teacher. All of these were designed in ways which sought to build upon the skills and knowledge which the students and the teacher had deemed necessary to solve the larger problem of the construction of a raft.

STUDENTS' DIRECTION

Do students determine specific activities or outcomes of the lesson?

Student direction of activities sees them influence what specific activities and/or tasks they will do in the period, and/or how these will be realised. Such tasks are likely to be student-centred, as in group work or individual research and/or investigative projects, whereby the students assume responsibility for the activities with which they engage, and/or how students complete them. Where students do not influence the class activities, the teacher, or some other educational/ institutional authority, explicitly determines what activities students do, and hence how they will meet the specified objectives required within the period. The appropriateness of an activity towards meeting this criterion is thus decided by the teacher and/or external authority.

No student determination 1 . . . 2 . . . 3 . . . 4 . . . 5 Full student determination

1. *No student control. All activities for the period explicitly designated by the teacher for students.*
2. *Teacher makes initial selection of activity, but students exercise some control, through a choice of procedure or manner in which the task is completed.*
3. *Teacher makes initial selection of activity, but students exercise some control, through a choice of alternative activities prescribed by the teacher in addition to procedural choice.*
4. *Some deliberation/negotiation between teacher and students over the activity for the period, including the range of options and procedures.*
5. *Students' determination of their activity, its appropriateness and context. This may be either independent of, or dependent on, teacher regulation.*

Example:

A number of teachers were concerned about the engagement of year 8 students with the academic curriculum of the school.

A group of four teachers (a Social Science teacher, an English teacher, a Maths teacher and a Science teacher) with the support of the school administration decided to embark on an innovative program which sought to address this issue. Central to the philosophy behind the innovation was a commitment to student direction of activities.

When the year eight students entered the high school at the beginning of the year they were presented with two questions: 'What do you want to learn about yourself?' and 'What do you want to learn about the world?'. These questions have served as the basis of the year 8 curriculum. Students have been involved in the determination of both the content and the activities throughout the year.

This has been a most successful project in relation to changing the pedagogies of the teachers in ways which have engaged the students in productive learnings.

EXPLICIT QUALITY PERFORMANCE CRITERIA

Are the criteria for judging the range of student performance made explicit?

Explicit quality performance criteria are frequent, detailed and specific statements about what it is students are to do, to achieve. This may involve overall statements regarding tasks or assignments, or about performance at different stages in a lesson. While Implicit criteria are identified by lack or absence of written or spoken reference to criteria, requirements, benchmarks, levels of acceptable performance expected of students. This may not be an indicator of neglect but a deliberate strategy for students to discover or construct their own outcomes.

NOTE: The main focus of this scale is on the explicit statements of what constitutes high quality student performances. Criterion, requirements or benchmarks, which simply make explicit expectation of what constitutes completed work, do not make explicit, in themselves, what constitutes high quality performance.

Implicit 1 . . . 2 . . . 3 . . . 4 . . . 5 Explicit

1. *Teachers have not made any explicit statements of the expected learning outcomes, quality of performance required of the students.*
2. *Some procedural parameters, advanced organisers and aspects of the general direction of the lesson have been specified but students are working without explicit statement of outcomes.*
3. *Outcomes and criteria for some aspects of the quality of student performances are specified at least once during the lesson.*
4. *Outcomes and criteria for the quality of student performances have been specified more than once in the lesson (but not repeatedly).*
5. *Outcomes and criteria for student performances are specified in detailed and exact ways repeatedly throughout the lesson with a focus on the quality of outcomes being reinforced.*

Example:

In a Stage 3 class the students worked in teams to create school newspapers. The students were allocated clearly defined roles such as editor, sub-editor, reporter and photographer. Each role required familiarity with a particular writing style, such as news reports, comment pieces and editorials. The newsworthiness of photographs and cartoons was also assessed. As well as their allocated role all students were expected to sub-edit material written for the paper and, thus, were involved in a number of drafting/re-drafting exchanges. Access to numerous actual newspapers provided a ready supply of benchmarks against which students could evaluate their own work and the cyclic nature of the writing/sub-editing pieces repeatedly reinforced what counts as high quality performance. The teacher drew the students' attention to the structural features of the genre of each written piece on a regular basis.

SOCIAL SUPPORT

Is the classroom characterized by an atmosphere of mutual respect and support among teacher and students?

Social support is present in classes when the teacher supports students by conveying high expectations for all students. These expectations include: that it is necessary to take risks and try hard to master challenging academic work, that all members of the class can learn important knowledge and skills, and that a climate of mutual respect among all members of the class contributes to achievement by all. Mutual respect means that students with less skill or proficiency in a subject are treated in ways that continue to encourage them and make their presence valued. If disagreement or conflict develops in the classroom, the teacher helps students resolve it in a constructive way for all concerned.

A lack of social support will be evidenced when teacher or student behaviour, comments and actions discourage effort, participation and taking risks to learn or express one's views. For example, teacher or student comments that belittle a student's answer, and efforts by some students to prevent others from taking seriously an assignment serve to undermine support for achievement. Support can also be absent in a class when no overt acts like the above occur, but the overall atmosphere of the class is negative due to previous behaviour. (Note: Token acknowledgements by teacher of student actions or responses do **not** *constitute evidence of social support.)*

Negative social support 1 . . . 2 . . . 3 . . . 4 . . . 5 High positive social supports

1. *Social support is negative; actions/comments by teacher or students result in "put-downs"; classroom atmosphere is negative.*
2. *Social support is mixed. Both negative and positive behaviours and comments are observed.*
3. *Social support is neutral or mildly positive. Evidence may be mainly in the form of verbal approval from the teacher for student effort and work. However, such support tends to be given to those who are already taking initiative in the class, and it tends not to be given to those who are reluctant participants or less articulate or skilled in the subject, or given in compensation for negative peer social interaction.*
4. *Social support from the teacher is clearly positive and there is some evidence of social support among students for their peers. Evidence of special efforts by the teacher takes the form of direct expressions that convey high expectations for all; mutual respect; a need to try hard and risk initial failure.*
5. *Social support is strong; the class is characterized by high expectations, challenging work, strong effort, mutual respect and assistance in achievement for all students. Both teacher and students demonstrate a number of these attitudes by soliciting and welcoming contributions from all students who are expected to put forth their best efforts. Broad participation may be an indication that low achieving students receive social support for learning.*

Example:

In a Year 12 Art class, students were in the closing stages of work on a self-directed, themed, multi-media project which formed part of their major assessment for the year. These works in progress were permanently displayed in the classroom.

At the beginning of the lesson the students made quick charcoal sketches which related to the theme of their major work. The students then rotated around these quick, warm up sketches and added a quick sketch of their own. When the warm up sketching was finished, the students were invited to move freely about the room making observations and comments upon each other's' work. The students and the teacher made thoughtful comments upon the work, not only providing positive feedback but also making relevant suggestions for improvement.

As this lesson progressed the students frequently asked the teacher and other students for feedback on their work. This example of a socially supportive classroom not only illustrates the teacher as supportive, but also illustrates students supporting and encouraging each other in the development of their project. Furthermore, this activity encouraged students to take risks by seeking and providing comments which could contribute to the improvement of their project.

ACADEMIC ENGAGEMENT

Are students engaged and on task during the lesson?

Engagement is identified by on-task behaviours that signal a serious psychological investment in class work; these include attentiveness, doing the assigned work, and showing enthusiasm for this work by taking initiative to raise questions, contribute to group tasks and help peers.

Disengagement is identified by off-task behaviours that signal boredom or a lack of effort by students; these include sleeping, day dreaming, talking to peers about non-class matters, making noise or otherwise disrupting the class. It is assumed these behaviours indicate that students are not taking seriously the substantive work of the class.

Disengagement 1...2...3...4...5 Engagements

1. *Disruptive disengagement; students are frequently off-task as evidenced by gross inattention or serious disruptions by many; this is the central characteristic during much of the class.*
2. *Passive engagement; most students, most of the time, either appear lethargic or are only occasionally active in carrying out assigned activities and some students are clearly off-task.*
3. *Sporadic or episodic engagement; most students either appear indifferent or are only occasionally active in carrying out assigned activities but very few students are clearly off-task.*
4. *Engagement is widespread; most students, most of the times are on-task pursuing the substance of the lesson; most students seem to be taking the work seriously and trying hard.*
5. *Serious engagement but not universal; almost all students are deeply involved, almost all of the time, in pursuing the substance of the lesson.*

Example:

Some Year 8 students were engaged in writing CD reviews. The students had each chosen a CD to review, with the selections ranging from country music (e.g. Garth Brooks) to pop music (e.g. Backstreet Boys). All of these selections were valued and accepted.

The students studied music reviews from a variety of sources such as magazines, newspapers and from the Internet. Through whole group and small group discussion the teacher and students developed a set of criteria for the CD reviews. Nearly all the students were highly engaged and focused throughout this piece.

Engagement with this activity was illustrated through enthusiastic discussion and questioning during the development of the review criteria and in the ensuing drafting of the CD reviews.

STUDENT SELF REGULATION

Is the direction of student behaviour implicit and self-regulatory?

High implicit control is identified by teachers not or not having to make statements that aim to discipline students' behaviour (e.g., you're not being good today, put your pens away) or to regulate students' bodily movements and dispositions (e.g., 'sit down', 'stop talking', 'eyes this way').

Low implicit control is identified by teachers who devote a substantial amount of verbal work to disciplining behaviour and regulating bodies.

Low implicit control 1 . . . 2 . . . 3 . . . 4 . . . 5 High implicit controls

1. *Teachers devote over half of their classroom talk issuing orders, commands and injunctions, and punishments to regulate student behaviour, movement and bodily disposition. It appears that more time and effort is devoted to control than to teaching and learning.*
2. *A substantial amount of the lesson time is taken engaged in disciplinary and regulatory talk. There is substantial interruption to the lesson.*
3. *Teachers must regulate students' behaviour several times during a lesson, perhaps focusing on specific groups or individuals who are out of control; however the lesson proceeds coherently.*
4. *Once or twice during the lessons, teachers must correct student behaviour or movement. There is only minor interruption to the lesson.*
5. *There is virtually no teacher talk which focuses on student behaviour or movement. The lesson proceeds without interruption.*

Example:

A Year 8 Social Studies teacher wrote two letters about an event that might have occurred in the classroom the day before. The two letters were written from different perspectives, one from that of the teacher and one from the perspective of a student. The views presented were largely divergent around the same issue.

The teacher very cleverly and creatively utilized discussion about these two letters to pursue the issue of evidence in historical research and writing. Many issues were raised, including, power and the production of knowledge and its links to veracity, along with knowledge/power relationships. There was also extensive discussion about the creation of historical narratives and analysis and the use of historical sources.

One of the striking features of this lesson was the studious and enthusiastic way in which the students engaged in this activity. Because of its perceived relevance they were eager to pursue the discussion and monitored their own and their peers' behaviour. This ensured a range of contributions from some of the less vocal students.

CULTURAL KNOWLEDGES

Are non-dominant cultural knowledges valued?

Cultures are valued when there is explicit valuing of their identity represented in such things as beliefs, languages, practices, and ways of knowing. Valuing all cultural knowledges requires more than one culture being present, and given status, within the curriculum. Cultural groups are distinguished by social characteristics such as gender, ethnicity, race, religion, economic status, or youth. Thus, their valuing means legitimating these cultures for all students, through the inclusion, recognition and transmission of this cultural knowledge.

Devaluing of cultures is apparent when curriculum knowledge is constructed and framed within a common set of cultural definitions, symbols, values, views and qualities, thus attributing some higher status to it.

Only high status culture 1 . . . 2 . . . 3 . . . 4 . . . 5 Multiple cultural knowledges

1. *No explicit recognition or valuing of other than the dominant culture in curriculum knowledge transmitted to students.*
2. *Some inclusion of Others' cultures, with weak valuing, through simple reference to a particular feature(s) of them or their existence.*
3. *Stronger valuing in curriculum knowledge, by acknowledgment and recognition of multiple cultural claims to knowledge, and perhaps some activity based on an aspect of this, though still within the framework of a dominant culture.*
4. *Others' cultures explicitly valued in the content through equal inclusion and use of the knowledge/perspective of the group, alongside the dominant culture.*
5. *Different cultures equally valued in all curriculum knowledge, such that the concept of a dominant culture is excluded in both its content and form.*

Example:

A Year 11 Modern History class we observed was engaging with the issue of 'the stolen generation'. This class was largely made up of white-Anglo middle class students.

The teacher of this class situated 'the stolen generation' within the unit 'Imperialism and Racial Conflicts and Compromises'. He commented that he saw understanding the issues around the stolen generation as an essential component in the reconciliation process. During the course of the lesson, he drew on a number of texts written by Aboriginal people, including the Aboriginal singer/song writer Archie Roach. The students discussed a number of these texts and considered why saying 'sorry' is an important and controversial issue within contemporary Australia.

Note: Linked closely with knowledge presented as problematic, this dimension goes on to both recognise the social construction and hence conflicting nature of knowledge, and explicitly value that knowledge associated with sub-group cultures.

ACTIVE CITIZENSHIP

Are attempts made to encourage active citizenship within the classroom?

Active Citizenship acknowledges that in a democratic society all individuals and groups: have the right to engage in the creation and re-creation of that democratic society; have the right to participate in all of the democratic practices and institutions within that society; have the responsibility to ensure that no groups or individuals are excluded from these practices and institutions; have the responsibility to ensure a broad definition of the political includes all relationships and structures throughout the social arrangement.

Active Citizenship is present in any classroom in any subject domain when the teacher elaborates the meaning of such citizenship and facilitates its practice both within and without the classroom.

No active Citizenship 1 . . . 2 . . . 3 . . . 4 . . . 5 Prevalent active citizenship

1. *The citizenship rights of students and teachers are neither discussed nor practised within the classroom.*
2. *There is limited talk about the practice of active citizenship within the classroom.*
3. *There is some evidence and some talk about the content of, and possible practices of, active citizenship for teachers and students.*
4. *There is evidence of the practice of active citizenship within the class.*
5. *The practice of active citizenship is obviously prevalent and evident in practices and in relationships between students and the teacher, and students and students and in some instances will involve active participation in contemporary issues external to*

Example:

In a primary school all students were involved in a referendum to determine if the canteen would sell packets of chips. The process by which the 'yes' and 'no' cases were articulated and publicised modelled closely the referendum process observed by the children in the broader community.

Posters outlining the arguments for and against were placed around the school and lunch time debates were held to ensure that all children were involved and informed about the issues. After an extended dialogue within the school, ballot papers were distributed and a secret ballot was organised.

This example is indicative of a productive pedagogy across the school rather than simply located within one classroom.

NARRATIVE

Is the style of teaching principally narrative or is expository?

Narrative is identified as a sequence of events chained together. The use of narrative in lessons is identified by an emphasis in teaching and in student responses on structures and forms. These may include the use of personal stories, biographies, and historical accounts, literary and cultural texts.

Expository is identified as an emphasis on written, non-fiction prose, scientific and expository expression both in lesson teaching and student responses. Examples are descriptions, reports, explanations, demonstrations, documentaries.

Only expository 1 . . . 2 . . . 3 . . . 4 . . . 5 All narrative

1. *At no point is narrative used in the lesson, all teaching and content remains expository.*
2. *Narrative is present in either the processes or content of the lesson, but the use of this narrative may only be on occasion or as a minor deviation from the main portion of the lesson.*
3. *The lesson processes and content are evenly split between narrative and expository forms.*
4. *Lesson processes and content primarily narrative in nature, but exposition is used on occasion or as a minor deviation from the main portion of the lesson.*
5. *Almost all of the lesson processes, and almost all of the lesson content is narrative.*

Example:

In one year 6 Social Science class a teacher was dealing with the sensitive topic of racism and Aboriginal and Torres Strait Islander studies. He provided a detailed description of his childhood experiences in a small provincial city. He gave a very clear account of this story through a child's eyes.

He then told the class about his recent visit to an Aboriginal and Torres Strait Islander museum in his childhood town. It was only then that he came to understand the difficulties and oppressions which Aboriginal people in his town had faced. He spoke of racism, and of that of the townsfolk, which was a product of the lack of knowledge about historical issues relating to Aboriginal and Torres Strait Islander peoples.

This narrative was very powerful device for demonstrating the impact of racism on a child's interpretation of the world. It was clearly more powerful than many an exposition on racism.

GROUP IDENTITIES IN LEARNING COMMUNITIES

Does the teaching build a sense of community and identity?

Contemporary social theory emphasises the need for schools to create learning communities in which difference and group identities are positively recognised and developed within a collaborative and supportive classroom community. This requires going beyond a simple politics of tolerance. A classroom which manifests this ideal is one where differences and group identities are both positively developed and recognised while at the same time a sense of community is created. For example, in a given classroom, Aboriginal identities are given positive recognition in classroom practices and representations; Aboriginal students and teachers are given opportunities to pursue aspects of the development of Aboriginal identities and cultures; all class participants value this as a positive and legitimate aspect of their classroom community; and racism is challenged within the classroom, school, and wider communities.

No evidence of community Development and positive

Or production of difference, recognition of difference

Focus on individuals 1 . . . 2 . . . 3 . . . 4 . . . 5 within community

1. *No evidence of community within the classroom; no positive recognition of difference and group identities; and no support for the development of difference and group identities. Students are all treated as individuals.*
2. *Limited evidence of community exists within the classroom; no positive recognition of difference and group identities; and no support for the development of difference and group identities.*
3. *Some evidence of community exists within the classroom; some recognition of difference and group identities; and no support for the development of difference and group identities.*
4. *There is a strong sense of community within the classroom; positive recognition of difference and group identities; and limited support for the development of difference and group identities.*
5. *There is strong sense of community within the classroom; positive recognition of group identities; and a supportive environment for the production of difference and group identities.*

Example:

A Stage 1 class was asked to bring to class a list of important dates for their family so that they could be added to the class calendar. The students were asked to find important religious dates, cultural festivals and family celebrations – these were all added to the class calendar and each week students were invited to share their experiences through talks, writing and photographic displays.

REPRESENTATIVE PARTICIPATION

Are deliberate attempts made to increase the participation of the range of students?

Representative participation describes the degree to which non-dominant groups are represented in classroom practices by participation. Non-dominant groups are identified in relation to broad societal-level dimensions of social inclusion/exclusion.

Lack of Representative participation is apparent when the students' backgrounds are ignored and they are treated as a homogenous group. This often results in some groups being unable or unwilling to contribute.

Low inclusion 1 . . . 2 . . . 3 . . . 4 . . . 5 High inclusions

1. *No participation of non-dominant social groups.*
2. *One or two instances of non-dominant social group participation.*
3. *Several instances of non-dominant social group participation.*
4. *Participation of non-dominant social groups for at least half of the lesson, but not all (nor nearly all) of the lesson.*
5. *Participation of non-dominant social groups for all, or nearly all, of the lesson.*

Example:

Students in a Stage 2 class which had a variety of backgrounds and socio-economic status had been studying a unit of work called "Places: Then, Now and tomorrow". There was a particular focus on the changes in the local community during the last 50 years as the school was celebrating its 50th Anniversary. The students visited a local historical home and took photos of the house, its rooms, fixtures and furniture using the schools' camera to compare with homes of today in the local community. The historic house also included a museum of artifacts and children's' toys. Students were then invited to bring in photos or sketches of their home to compare with the historic house.

In the classroom students worked in pairs to make generalizations from the photos about how lifestyles and families had changed during the past 50 years. The teacher carefully selected students to report to the class on their findings ensuring that students from different backgrounds contributed.

APPENDIX 5:
SUMMARY WORKSHOP MANUAL

Productive Pedagogies for Reforming Secondary School Mathematics Classroom Practice in Nigeria

Intellectual Quality:

In intellectual quality the teacher will want to ensure that students manipulate information and ideas in ways which transform their meaning and implications, understand that knowledge is not a fixed body of information, and can coherently communicate ideas, concepts, arguments and explanations with rich detail.

s/n	Elements	Example
1	**Higher order Thinking:** *Higher-order thinking requires students to manipulate information and ideas in ways that transform their meaning and implications. This transformation occurs when students combine facts and ideas in order to synthesise, generalise, explain, hypothesise or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allows students to solve problems and discover new (for them) meanings and understandings. When students engage in the construction of knowledge, an element of uncertainty is introduced into the instructional process and makes instructional outcomes not always predictable; i.e., the teacher is not certain what will be produced by students. In helping students become producers of knowledge, the teacher's main instructional task is to create activities or environments that allow them opportunities to engage in higher-order thinking.* *Lower-order thinking occurs when students are asked to receive or recite factual information or to employ rules and algorithms through repetitive routines. Students are given pre-specified knowledge ranging from simple facts and information to more complex concepts. Such knowledge is conveyed to students through a reading, work sheet, lecture or other direct instructional medium. The instructional process is to simply transmit knowledge or to practise procedural*	*When students use quadratic formula to solve mathematical problems in the class without the knowledge of its derivation does not show higher order thinking in the side of the teacher and the students. But if the mathematics teacher is able to show the students how the formula is derived using the completing the squares strategy and also use the formula with the students to solve similar problem then higher order thinking is used. The step by step process of deriving the formula requires higher order thinking in the side of the teacher. The steps show the intellectual quality of the topic. When the students are able to derive the formula on their own using different variables and are also able to use the formula derived to solve problems involving quadratic equations it indicates higher order thinking from the side of the students.*

	routines. Students are in a similar role when they are reciting previously acquired knowledge; i.e., responding to test-type questions that require recall of pre-specified knowledge. More complex activities still may involve reproducing knowledge when students only need to follow pre-specified steps and routines or employ algorithms in a rote fashion.	
2	**Depth of Knowledge:** *Knowledge is deep or thick when it concerns the central ideas of a topic or discipline and because such knowledge is judged to be crucial to a topic or discipline. Knowledge is deep when relatively complex connections are established to central concepts. Knowledge is shallow, thin or superficial when it is not connected with significant concepts or central ideas of a topic or discipline, and it is dealt with only in an algorithmic or procedural fashion. Knowledge is also shallow when important, central ideas have been trivialized by the teacher or students, or when it is presented as non-problematic. This superficiality can be due, in part, to instructional strategies such as when teachers cover large quantities of fragmented ideas and bits of information that are unconnected to other knowledge.*	*Think of the example above on quadratic equation. Just using the quadratic formula in solving problems without knowing how to derive it does not portrayed deep knowledge among the students it is regarded as shallow knowledge. However the ability to derive the formula and make application with the formula to solve problems in quadratic equations, and the ability to relate the quadratic equations in Algebra to solve problems and other equations in calculus and other areas of mathematics, shows that the students have acquired deep knowledge in using quadratic formula to solve all quadratic equations.*
3	**Deep Understanding:** *For students, knowledge is deep when they develop relatively complex understandings of these central concepts. Instead of being able to recite only fragmented pieces of information, students develop relatively systematic, integrated or holistic understandings. Mastery is demonstrated by their success in producing new knowledge by discovering relationships, solving problems, constructing explanations, and drawing conclusions. Students' understanding of important concepts or issues is taken to be superficial when ideas are presented by students in a way which demonstrates that they only have a surface acquaintance with the meaning. Evidence of shallow understanding by students exists when they do not or cannot use knowledge to make clear distinctions, arguments, solve problems and develop more complex understandings of other related phenomena.*	*From the above example also, the ability of the student to use other variables different from the ones the teacher uses to derive his own quadratic equation formula shows deep understanding from the side of the student. If this student is able to identify the relationship between the variables the teacher used and the ones the student is using and come up with the same quadratic formula though with different variables shows deep understanding in the side of the students. He's ability to also use his/her formula to solve quadratics equations of any kind is also an indication where student shows deep understanding. Another example involving matrices and determinants is when a student is able to use the knowledge of Matrices and determinants to solve simultaneous equations and differential equations are indication that the student has deep understanding of the concept of matrices algebra and he/she is using that knowledge in calculus.*
4	**Substantive Conversation:** *In classes with substantive conversation there is*	*Assuming the teacher came to the class*

	considerable teacher-student and student-student interaction about the ideas of a substantive topic; the interaction is reciprocal, and it promotes coherent shared understanding. This element describes the extent of talking to learn and to understand in the classroom. Features of substantive conversation include *i. Intellectual Substance: The talk is about subject matter in the discipline and encourages critical reasoning such as making distinctions, applying ideas, forming generalizations, raising questions. It moves beyond just the recounting of experiences, facts, definitions, or procedures (e.g., technical language, analytical distinctions and categories being made, levels of differentiations between types and arguments stated, grounds for disagreement stated).* *ii. Dialogue: The conversation involves sharing of ideas and is not completely scripted or controlled by one party (as in teacher-led recitation). Sharing is best illustrated when participants provide extended statements, direct their comments, questions and statements directly to others, redirect and select next speakers.* *iii. Logical Extension and Synthesis: The dialogue builds coherently on participants' ideas to promote improved collective understanding of a theme or topic. In short, substantive conversation resembles the kind of sustained exploration of content characteristic of a good seminar where student contributions lead to shared understandings (e.g., teachers and students may make principled topic shifts, may use linking words, make explicit references to pervious comments, and may summarise).* *iv. A Sustained Exchange extends beyond a routine IRE (initiate/ response/ evaluate). This can occur between teacher and students or student and student and involves several consecutive interchanges. Dialogue consists of a sustained and topically related series of linked*	*and write* $\sin^2\theta + \cos^2\theta = 1$ *Proof.* *The process of talking and receiving positive contribution from the students as to the step by step solution to the problem is what we call teacher/students interaction. For example if the teacher said.* *Teacher: what previous knowledge do we need to have to solve the problem above?* *Student A: Knowledge of right angle triangle.* *Student B: Knowledge of Pythagoras theorem.* *Student C: Knowledge of Both* *Teacher: Both responses are correct, however student A how do apply the knowledge of right angle triangle to solve this?* *Student A: Gives the explanation using the rules and the derivations* *Teacher: student B what about you?* *Student B. also use the same explanation based on the formula of Pythagoras theorem* *The process in which the interaction between the teacher and the students is the case of student/teacher interaction, also the teacher could group the students into smaller units to discuss and find solution to the above problem and work round the class to monitor and offer assistance to the week groups this is Teacher/Students and Students/ Students interaction. In fact, for any effective mathematics classroom practice teacher/ students conversation is compulsory, since mathematics is about problem solving and problems can only be solved when there is conversation between two or more people involve.*

	exchanges between speakers. *In classes where there is little or no substantive conversation, teacher-student interaction typically consists of a lecture with recitation where the teacher deviates very little from delivering information and routine questions; students typically give very short answers. Discussion here may follow the typical IRE pattern: with low-level recall/fact-based questions, short utterance or single-word responses, and further simple questions and/or teacher evaluation statements (e.g., 'yes, good'). This is an extremely routine, teacher-centred pattern, that amounts to a 'fill in the blank', or 'guess what's in the teacher's head' format.*	
5	**Knowledge as Problematic:** *Presenting knowledge as problematic involves an understanding of knowledge not as a fixed body of information, but rather as being constructed, and hence subject to political, social and cultural influences and implications. Multiple, contrasting, and potentially conflicting forms of knowledge are represented. Knowledge as given sees the subject content represented as facts that is a body of truth to be acquired by students. The transmission of the information may vary, but is based on the concept of knowledge as being static and able to be handled as property, perhaps in the form of tables, charts, handouts, texts, and comprehension activities.*	*Assuming in an Algebra class mathematics teacher came with a problem* $x - 3y = 5.$ $x + y = 13$ *Teacher: What is the appropriate strategy to be employed in solving this simultaneous equation and why?* *Student A: I prefer Substitution Method* *Student B: Preferred Elimination* *Student C: prefer using the graphical method* *Student D: prefers the Matrices and determinant Methods* *The students all gave their reasons of preference and showed to the class how the solution could be obtained using the method they choose. The different approaches to the solution to the simultaneous equation above show how problematic the knowledge of simultaneous equation is.*
6	**Metalanguage:** *High metalanguage instruction has high levels of talk about talk and writing, about how written and spoken texts work, about specific*	*The used of synonyms as applied in metacognition should be encourage to reduce the complex nature of mathematics Language. Teachers of*

	technical vocabulary and words (vocabulary), about how sentences work or don't work (syntax/grammar), about meaning structures and text structures (semantics /genre), about issues how discourses and ideologies work in speech and writing. Teachers tend to do a good deal of pulling back from activities, assignments, readings, lessons, and foregrounding particular words, sentences, text features, discourses, etc. Low metalanguage instruction has little explicit talk about talk and writing, about how written and spoken texts work, about their features, characteristics, patterns, genres and discourses. There is an emphasis on simply doing text-based activities, without any pulling back and talking about curriculum and evaluation of texts.	*mathematics should learn to pull back and explain relations found in complex mathematic, words like axioms, theories and corollaries especially when treating subjects like functional analysis, complex analysis, linear algebra, topology, abstract algebra that are mostly made up of axioms and theorems and relate them to real life situation to reduce its complex context.*

Connectedness or Relevance

On relevance the teacher will want to ensure that students engage with real, practical or hypothetical problems which connect to the world beyond the classroom, which are not restricted by subject boundaries and which are linked to their prior knowledge.

s/n	Definition	Example
1	**Knowledge Integration:** *Integrated school knowledge is identifiable when either: (a) explicit attempts are made to connect two or more sets of subject area knowledge, or (b) when no subject area boundaries are readily seen. Topics or problems which either require knowledge from multiple areas, or which have no clear subject areas basis in the first place are indicators of curricula which integrate school subject knowledge. Non-integrated school knowledge is typically segregated or divided in such a way those specific sets of knowledge and skills are (relatively) unique and discrete to each specified school subject area. Segregated knowledge is identified by clear boundaries between subject areas. Connections between knowledge in different segregated subject areas are less and less clear the stronger the dividing knowledge boundary. In the extreme, such boundaries prevent any interrelation of different subject areas.*	*An example of knowledge integration is that of a student who had studied the SI units in a mathematics class, solved problems in the class with other students, claimed to have understood the lesson properly but when the same student got to the Physic class found it difficult to link his knowledge of SI units in Mathematics and that of the physic class. This example is a clear case of lack of integration on the side of the student between the knowledge of SI units in mathematics and that of Physic. The teacher also had the problem of connectedness, if he had given the students some examples relating to physics this would make a link for the students to know that the concept of SI units in Mathematics is the same concept in Physics.*
2	**Students Background Knowledge:** *High-connection lessons provide students with opportunities to make connections*	*An example of a teacher teaching NCE two calculus who decided to start with integration instead of starting with*

	between their linguistic, cultural, world knowledge and experience and the topics, skills and competencies at hand. Background knowledge may include community knowledge, local knowledge, personal experience, media and popular culture sources. Low-connection lessons introduce new content, skills and competencies without any direct or explicit opportunities to explore what prior knowledge students have of the topic, and without any attempts to provide relevant or key background knowledge that might enhance students' comprehension and understanding of the 'new' material being offered.	*functions and differentiation. In this student comprehension will be affected as they need the knowledge of functions to learning differentiation and the knowledge of differentiation to learning integration. This implies that functions and differentiations are the background knowledge students need to have before integration in a calculus lesson.*
3	**Connectedness to the World:** *Connectedness describes the extent to which the lesson has value and meaning beyond the instructional context, making a connection to the larger social context within which students live. Two areas in which student work can exhibit some degree of connectedness are: (a) a real-world public problem; i.e., students confront an actual contemporary issue or problem, such as applying statistical analysis in preparing a report to the City Council on the homeless and (b) Students' personal experiences; i.e., the lesson focuses directly or builds upon students' actual experiences or situations. A high level of connectedness can be achieved when the lesson entails one or both of these. In a low-connectedness lesson with little or no value beyond the classroom, activities are deemed important for success only in school (now or later), but for no other aspects of life. Student work has no impact on others and serves only to certify their level of competence or compliance with the norms and routines of formal schooling.*	*A mathematics teacher, teaching mathematics in a commercial or social science class at the college of education need to relate his examples and problems given to students to the happenings in the commercial market, since the students are conversant with the happenings in the commercial world, they will be able to picture what is going on there and relate it to their classroom practice.*
4	**Problem Based Curriculum:** *A problem-based curriculum is identified by lessons in which students are presented with a specific practical, real, or hypothetical problem (or set of problems) to solve. Problems are defined as having no specified correct solution, requiring knowledge construction on the part of the students, and requiring sustained attention beyond a single lesson.*	*Every Mathematics problem has a solution; however there are different ways of approaches. A problem base curriculum is basically a mathematics problem that will require students using ideas from other concepts to solve. For example* *Think of a quadratic inequality* $f(x) = ax^2 + bx + c$ *be a function or expression where* $a,b,c \leq R$ *And* $a \neq 0$ *then* $f(x) \geq o$, $f(x) > 0$, $f(x) < 0$

		and $f(x) \leq 0$ Are known as quadratic inequality *Then if the Student is required to text the function $f(x) = ax^2 + bx + c$ based on some domains or conditions, the processes of the test of these conditions makes the problem problematic. If the condition holds in the first domain the student still has to check if the other condition does not holds because in every inequality of a quadratic function there is only one domain of the conditions that most hold. These domains are.* *When $b^2 - 4ac > 0$ the roots are real and distinct or when $b^2 - 4ac = 0$, the roots are real and equal and when $b^2 - 4ac < 0$, the roots are non-real or complex and distinct roots* *In all these, there are different methods of testing and solving the quadratic inequality functions. This is the case of a problematic curriculum or problem solving curriculum in mathematics.*

Supportive Classroom Environment

In supportive classroom environment the teacher will want to ensure that students influence the nature of the activities they undertake, engage seriously in their study, regulate their behaviour, and know of the explicit criteria and high expectations of what they are to achieve.

s/n	Definition	Example
1	**Social Support:** *Social support is present in classes when the teacher supports students by conveying high expectations for all students. These expectations include: that it is necessary to take risks and try hard to master challenging academic work, that all members of the class can learn important knowledge and skills, and that a climate of mutual respect among all members of the class contributes to achievement by all. Mutual respect means that students with less skill or proficiency in a subject are treated in ways that continue to encourage them and make their presence valued. If disagreement or conflict develops in the classroom, the teacher helps*	*Social support is always necessary during mathematics classroom practice, it is required that students are encourage to work in groups, or when problems solving in the class the teacher work round the class and see what the students are doing to offer support when students are discover to be working out of point. Positive remarks during classroom practice and other forms of motivations are part of social support given during mathematics classroom practice. In a situation where girls are generally regarded as weak in Mathematics portrayed a situation where social support is highly required. Assuming girls with good understanding of mathematics attempts to answer or contribute meaningfully to classroom conversations in a mathematics class and boys, instead of appreciating and*

	students resolve it in a constructive way for all concerned. *A lack of social support will be evidenced when teacher or student behaviour, comments and actions discourage effort, participation and taking risks to learn or express one's views. For example, teacher or student comments that belittle a student's answer, and efforts by some students to prevent others from taking seriously an assignment serve to undermine support for achievement. Support can also be absent in a class when no overt acts like the above occur, but the overall atmosphere of the class is negative due to previous behaviour. (Note: Token acknowledgments by teacher of student actions or responses do not constitute evidence of social support.)*	*encouraging them, decided to silence the girls or give them names (as it is commonly done in Nigeria) like "Our female Chike Obi" or "our new Alele Williams had emerged". This type of comments does not reflect a case of effective classroom support. These students need to be spoken to and such attitude be discouraged by the teacher and the girls encouraged to offer any meaningful contribution they have to the progress of classroom activities, no matter how minuet the contribution is. In this the teacher will encourage the free flow of information and participation in the class irrespective of sex, gender and race.* *Another Example shows the conversation of two students in a mathematics classroom about their teacher* *Student1: The mathematics teacher that we used to have was horrible. If we ask her question her response will not be friendly, she will like say 'No I've just explained that to you.' But she didn't know how to explain it.* *Students 2: And you did not walk away feeling like you knew it.* *Student 1: But this teacher I have now, sits down and explains it to us, it doesn't matter how many times you go to her with a problem, she does it because she knows it, and I'm doing so much better now, like I'm actually understanding mathematics better now, and not just going, 'but for the other teacher, you're in trouble because you don't understand it'. She was pathetic.* *Student 2: that is good*
2	**Academic Engagement:** *Academic engagement is identified by on-task behaviours that signal a serious psychological investment in class work; these include attentiveness, doing the assigned work, and showing enthusiasm for this work by taking initiative to raise questions, contribute to group activities and help peers. Disengagement is identified by off-task behaviours that signal boredom or a lack of effort by students; these include sleeping, day dreaming, talking to peers about non-class matters, making noise or*	*Assuming in an Algebra class, the mathematics teacher came with a problem* $x - 3y = 5.$ $x + y = 13$ *And decided to group the class into groups and asked them to solve the equation above using any of the four methods outline above and that no two groups should use the same method. Each of the group will be busy working in order to find solution to the equation. Consultations within and outside the group with the aim of coming out with the*

	otherwise disrupting the class. It is assumed these behaviours indicate that students are not taking seriously the substantive work of the class.	*same solution is allow. To make the activity more academic, the lecturer decided to ask the students to discuss the method they employed and why the decided to use the method they chose and also they are to choose one person from the group to show how they got their solution with the other members of the class. This is the case of academic engagement.*
3	**Self-Regulation**: *High implicit control is identified by teachers not making or not having to make statements that aim to discipline students' behaviour (e.g., 'you're not being good today, put your pens away') or to regulate students' bodily movements and dispositions (e.g. Sit down', 'stop talking', 'eyes this way'). Low implicit control is identified by teachers who devote a substantial amount of verbal work to disciplining behaviour and regulating student movement.*	*The ability to get all the students engaged in the activities above and every member of the class is working and concentrating on the subject, is an indication of high level of self-control among the students and the teacher will spend less time talking about the undisciplined students. But in the situation where some students fail to participate in the activity they will engaged themselves into another activity irrelevant to the classroom activities is the case of low self-control.*
4	**Students Direction**: *Student direction sees students influence what specific activities or tasks they will do in the period, or how these will be realised. Such activities are likely to be student-centred, as in group work or individual research or investigative projects. In this way the students assume responsibility for the activities with which they engage, or how students complete them. A low level of student direction is exhibited where students do not influence the class activities and the teacher, or some other educational /institutional authority, explicitly determines what activities students do, and hence how they will meet the specified objectives required within the period. The appropriateness of an activity towards meeting these criteria is thus decided by the teacher and/or external authority.*	*Assuming in an Algebra class, the mathematics teacher came with a problem* $3x - y = 5.$ $x + 3y = 1$ *And decided to group the class into groups and asked them to solve the equation above using any of the four methods outline above and that no two groups should use the same method. Each of the group will be busy working in order to find solution to the equation. Consultations within and outside the group with the aim of coming out with the solution is allow. To make the activity more students centred, the lecturer decided to ask the students to discuss the method they employed and why the decided to use the method they chose and also they are to choose one person from the group to show how they got their solution with the other members of the class. The processes of selecting the group leader and also the person to defend their solution, their reasons for using the method they choose and how they come about the solution is done by the students and is an indication that students are constructing their own learning and they are in control of the learning activities that is going on. This form of instruction is generally consistent with the current push for the constructivist learning strategy as*

		proposed by NCTM (1989) and also the students to determination and monitoring of their learning as emphasized by metacognitive research theory by Biggs (1992).
5	**Explicit Quality Performance Criteria***: Explicit quality performance criteria are frequent, detailed and specific statements about what students are to do and to achieve. This may involve overall statements regarding tasks or assignments, or about performance at different stages in a lesson. Implicit criteria are identified by lack or absence of written or spoken reference to criteria, requirements, benchmarks or levels of acceptable performance expected of students. This may not be an indicator of neglect but a deliberate strategy for students to discover or construct their own outcomes.*	*Assuming in an Algebra class, the mathematics teacher came with a problem Solve the quadratic equation* $x^2 - 5x - 6 = 0$ *using any of the strategy you feel simple***.** *The performance criteria here is that the students should find the solution to the above quadratic equation. No method was specified.* *Student A: may decide to use completing the square.* *Student B: may decide to use quadratic formula.* *Student C: may decide to use substitution* *In any of the method the student decided to use is correct because the teachers' instruction was that the student is to use the method of his choice. Here the interest of the teacher is the solution and not the method used by the student to arrive at the solution. Here the teacher's performance goal was well stated.*

Recognition of Difference:

On the Recognition of difference the teacher will want to ensure that students know about and value a range of cultures, create positive human relationships, respect individuals, and help to create a sense of community.

s/n	Definition	Example
1	**Cultural Knowledge:** *Cultures are valued when there is explicit valuing of their identity represented in such things as beliefs, languages, practices, and ways of knowing. Valuing all cultural knowledge requires more than one culture being present, and given status, within the curriculum. Cultural groups are distinguished by social characteristics such as gender, ethnicity, race, religion, economic status, or age. Thus, their valuing means legitimating these cultures for all students, through the inclusion, recognition and transmission of this cultural knowledge. Devaluing of cultures is apparent when curriculum knowledge is constructed and framed within a common*	*In a society where girls are generally regarded as weak in Mathematics portrayed a situation Cultural knowledge. Assuming girls with good understanding of mathematics attempts to answer or contribute meaningfully to classroom conversations in a mathematics class and boys, instead of appreciating and encouraging them, decided to silence the girls or give them names (as it is commonly done in Nigeria) like "Our female Chike Obi" or "our new Alele Williams had emerged". This type of comments does not reflect a case of effective classroom practice. These students are acting base on the cultural believe that girls are not*

	set of cultural definitions, symbols, values, views and qualities, thus attributing some higher status to it	*meant to do well in mathematics and mathematics related subjects. The believe that females are best managers and should manage their homes instead of doing complex mathematics, is a mere cultural believe and should discarded and discourage by mathematics lecturers during mathematics instruction.*
2`	**Inclusivity:** *Inclusivity describes the degree to which non-dominant groups are represented in classroom practices by participation. Non-dominant groups are identified in relation to broad societal-level dimensions of social inclusion/ exclusion. Lack of inclusivity is apparent when the students' backgrounds are ignored and they are treated as a homogenous group. This often results in some groups being unable or unwilling to contribute.*	*An example of an elderly man in an NCE mathematics class who have children of the same age with the students in the mathematics class. This elderly mathematics student found he in this school so late because he had been a grade two teacher for a long time and since he could no more be promoted to a higher level until an additional qualification is presented, decided to go back to school. It will be very difficult for this elderly mathematics student to flow with other students in the class because of the age. And learning will be very difficult as the classmates will call him Baba hence he will also find it difficult to contribute to the lesson in the class. The mathematics teacher in this case should make sure this elderly man is not left behind. He should be made to accept the challenge and learnt along with the young students in the class and the students in the class should be made to accept the elderly student in the class.*
3	**Narratives:** *Narrative is identified as a sequence of events chained together. The use of narrative in lessons is identified by an emphasis in teaching and in student responses on structures and forms. These may include the use of personal stories, biographies, and historical accounts, literary and cultural texts. Expository is identified as an emphasis on written, non-fiction prose, scientific and expository expression both in lesson teaching and student responses. Examples are descriptions, reports, explanations, demonstrations, documentaries.*	*In every mathematics problem there are always procedures and steps to follow to arrive at the solutions. These steps by steps procedures could be term the mathematical narratives. Also in a practical way, assuming students in the class did not understand what the teacher said in a particular mathematical problem. The teacher could ask a student that understood the concept to narrate the concept to this student because most at times students understand their peers better than the teacher, as the gap between teacher and students will not be there. This is particular important when dealing with students from low socio economic status.*
4	**Group Identity:** *Group identity in contemporary social theory emphasises the need for schools to create learning communities in which difference and group identities are positively recognised and developed within a collaborative and supportive classroom community. This*	*For example, in a given mathematics classroom, the local community identities should be given positive recognition in classroom practices and representations this could be in the form of using names that are common and relevant to the local community when*

	requires going beyond a simple politics of tolerance. A classroom which manifests this ideal is one where differences and group identities are positively developed and recognised while at the same time a sense of community is created.	*solving word problems especially as examples, you can also make some illustrations using the happening in the local community; In the local community, students and teachers should be given opportunities to pursue aspects of the development of the local community identities and cultures; all class participants Should value this as a positive and legitimate aspect of their classroom community; and racism is challenged within the classroom, school, and wider communities.*
6	**Active Citizenship:** *Active citizenship acknowledges that in a democratic society all individuals and groups have the right to engage in the creation and re-creation of that democratic society; have the right to participate in all of the democratic practices and institutions within that society; have the responsibility to ensure that no groups or individuals are excluded from these practices and institutions; have the responsibility to ensure a broad definition of the political includes all relationships and structures throughout the social arrangement. Active citizenship is present in any classroom in any subject domain when the teacher elaborates the meaning of such citizenship and facilitates its practice both within the classroom and outside.*	*From the example above, it was said that in a given mathematics classroom, the local community identities should be given positive recognition in classroom practices and representations; the same thing should be applied to those who are non-members of the community in which the school is located, students and teachers should be given opportunities to pursue aspects of the community development of the local community identities and cultures; all class participants Should value this as a positive and legitimate aspect of their classroom community; and racism is challenged within the classroom, school, and wider community.*

APPENDIX 6
DATA COLLECTION IN PHASES

Phase 1

We ek	Cycle	Participating Teachers	Year group	Topic	Observatio n	Researcher Observation	Video tapped
1-3	***Obtaining permission from sample schools, Selection of participating teachers, the focus group students, and Collection of research materials by the participating teachers***						
4	***Workshop***					***Video-tapped***	
5	*1* *First Lesson*	*Jimmy*	*SS2*	*Solving problems relating to Surd*	*Yes*	*Casual*	*No*
		Jerry	*SS2*	*Solving problems relating to AP*	*Yes*	*Casual*	*No*
		Jackson	*SS2*	*Solving problems relating to GP*	*Yes*	*Casual*	*No*
		Jennie	*SS2*	*Solving Problems relating to Indices and Logarithms*	*Yes*	*Casual*	*No*
		Casual Interviews were conducted with the participating teachers and t some selected students					
6	*1* *Second Lesson*	*Jimmy*	*SS2*	*Using Factorization Method to Solving Quadratic Equation*	*Yes*	*Casual*	*No*
		Jerry	*SS2*	*Using Completing the Square Method to Solving Quadratic Equations*	*Yes*	*Casual*	*No*
		Jackson	*SS2*	*Development and Application of Quadratic Formula*	*Yes*	*Casual*	*No*
		Jennie	*SS2*	*General Problem Leading to Quadratic Equations*	*Yes*	*Casual*	*No*

				using Factorization, Completing The Squares and The Quadratic Formula.			
		First Planning and Reflection Meetings with the participating teachers and First Focus Groups with the Focus group Students					***Video-tapped***
7	*2 First Lesson*	*Jimmy*	*SS2*	*Word Problems Leading to Quadratic Equations*	*Yes*	*Casual*	*No*
		Jerry	*SS2*	*Graphical Solutions to Quadratic Equations*	*Yes*	*Casual*	*No*
		Jackson	*SS2*	*General Problems Leading to Quadratic Equation 1*	*Yes*	*Casual*	*No*
		Jennie	*SS2*	*General Problems Leading to Quadratic Equations 2*	*Yes*	*Casual*	*No*
		Casual Interviews were conducted with the participating teachers and t some selected students					
8	*2 Second Lesson*	*Jimmy*	*SS2*	*Methods of Solving Simultaneous Equation 2 (Elimination Method)*	*Yes*	*Casual*	*No*
		Jerry	*SS2*	*Methods of Solving Simultaneous Equations 1 (Substitution Method)*	*Yes*	*Casual*	*No*
		Jackson	*SS2*	*Problems Leading to Simultaneous Equations (Using Substitution and Elimination Methods*	*Yes*	*Casual*	*No*
		Jennie	*SS2*	*Introduction to Simultaneous Equations*	*Yes*	*Casual*	*No*

		Second Planning and Reflection Meetings with the participating teachers and Focus Groups discussion with the Students					***Video-Tapped***
9	*3 First Lesson*	*Jimmy*	*SS2*	*Problems Leading to Simultaneous Equations (Graphical Solutions to Simultaneous Equations*	*Yes*	*Casual*	*No*
		Jerry	*SS2*	*Graphical Solutions to Simultaneous Equations*	*Yes*	*Casual*	*No*
		Jackson	*SS2*	*Words Problems Leading to Simultaneous Equations 1*	*Yes*	*Casual*	*No*
		Jennie	*SS2*	*Words Problems Leading to Simultaneous Equations 2*	*Yes*	*Casual*	*No*
		Casual Interviews were conducted with the participating teachers and t some selected students					
10	*3 Second Lesson*	*Jimmy*	*SS2*	*Revision on Quadratics Equations*	*Yes*	*Yes*	*Yes*
		Jerry	*SS2*	*Revision on Simultaneous Equation*	*Yes*	*Yes*	*Yes*
		Jackson	*SS2*	*Revision Indices, Surd and Logarithms*	*Yes*	*Yes*	*Yes*
		Jennie	*SS2*	*Revision on Series and Sequence*	*Yes*	*Yes*	*Yes*
		Third Planning and Reflection Meetings with the participating teachers and Focus Groups discussions with Students					***Video Tapped***
11-13	***Compilations of research findings and presentation of findings by the participating teachers***						***Video taped***

Phase 2

S/N	***Week***	***Participating Teacher***	***Year Group***	***Topic***	***Researcher Observation***	***Video Taped***
1	*1* *Day 1*	*Jerry*	*SS1 Arts/Commercial*	*Introduction to Circle Theory (Mensuration)*	*Yes*	*Yes*
		Jackson	*SS1 Science*	*Introduction to Circle Theory (Mensuration)*	*Yes*	*Yes*
	3 *Day 1*	*Jimmy*	*JSS3A*	*Applications of Trigonometric Ratios 1((Sine and Cosine)*	*Yes*	*Yes*
		Casual Interviews were conducted with the participating teachers and t some selected students				
2	*1* *Day 2*	*Jerry*	*SS1 Arts/Commercial*	*Circle Theory1 (Area And Perimeter)*	*Yes*	*Yes*
		Jackson	*SS1 Science*	*Circle Theory1 (Area And Perimeter)*	*Yes*	*Yes*
	3 *Day 2*	*Jimmy*	*JSS 3B*	*Applications of Trigonometric Ratios 1(Sine and Cosine)*	*Yes*	*Yes*
		Casual Interviews were conducted with the participating teachers and some selected students				
	2 *Day 1*	*Jerry*	*SS1 Arts/Commercial*	*Circle Theory 2 (Length of Arc)*	*Yes*	*Yes*
		Jackson	*SS1 Science*	*Circle Theory 2 (Length of Arc)*	*Yes*	*Yes*
	4 Day 1	*Jimmy*	*JSS 3A*	*Applications of Trigonometric Ratios 2 (Tangent of an Angle)*	*Yes*	*Yes*
		Casual Interviews were conducted with the participating teachers and some selected students				
	2 *Day 2*	*Jerry*	*SS1 Arts/Commercial*	*Circle Theory 2 (Length of Chord)*	*Yes*	*Yes*
		Jackson	*SS1 Science*	*Circle Theory 2 (Length of Chord)*	*Yes*	*Yes*
	Week 4 *Day 2*	*Jimmy*	*JSS3B*	*Applications of Trigonometric Ratios 2(Tangent of an Angle)*	*Yes*	*Yes*
		Casual Interviews were conducted with the participating teachers and some selected students				
	Week 5	***Compilations of Results and collections of The participants Lessons notes***				

APPENDIX 7

INTERVIEW SCHEDULE OR GUIDE

Some Selected Discursions from Planning and Reflection Meeting and Focus Group Discussions

This study aimed to investigates the process and the effect of introducing Productive Pedagogies into mathematics classroom in Nigerian secondary schools. In Chapter 1 of this study the researcher discussed the rationale for developing and introducing the framework to the Nigerian mathematics classroom. Five research aims were developed to guide this study. These aims involve investigating

6. *The scaffolding needed by participating teachers to implement the Productive Pedagogies framework;*
7. *The changes in classroom practice as a result of the participating teachers' implementation of Productive Pedagogies framework;*
8. *The participating teachers' reflections on the effect of Productive Pedagogies framework on their practice.*
9. *The perceptions of students on the effects of Productive Pedagogies framework on their engagement.*
10. *The challenges that participating teachers encountered while introducing Productive Pedagogies.*

In attempt to achieve the above aims the following questions guided the discussions during focus groups and reflections and planning meetings.

5. *From your observations and rating of the classroom practice of your colleague using the Productive Pedagogies Classroom Observation Manual. Discussed the strength and weaknesses observed from the participating teachers according to the dimension chosen.*
6. *Are there possible suggestions that could be used to enhance the participating teachers teaching using the Productive Pedagogies framework?*
7. *To what extents where did the participating teachers created opportunities for students' engagement in mathematics as observed during the cycle?*
8. *What are your views about the framework generally as regards achieving quality classroom instruction in the Nigerian classroom?*

1. Planning and Reflection Meeting Sample Discussion

Speaker	***Comment Made***	***Coding***
Moderator	*We are starting this reflection with Jimmy's Classroom teaching. We are going to look at what he was doing, how his teaching is using Intellectual Quality dimension of Productive Pedagogies and what are the problems observed in his teaching using Intellectual Quality dimension of Productive Pedagogies in reforming his mathematics classroom practice. And finally we shall look at the possible ways he could use to improve his practice.* *Jimmy was working on the Intellectual Quality dimension of Productive Pedagogies. Can we mention the elements under this dimension please?*	
Researchers	➢ *Higher Order Thinking* ➢ *Depth of Knowledge* ➢ *Depth of Understanding* ➢ *Substantive Conversation* ➢ *Knowledge as Problematic* ➢ *Metalanguage*	
Moderator	*Can we identify some problems observed in Jimmy classroom practice in cycle one*	
Jackson	*He was nervous that is he was not confident in the presentation of he's facts to the students during he's classroom practice. Other problems I observed in his mathematics classroom practice include; There was weak classroom control, as the teacher did not really have the grip of the class he was teaching. The management of the chalk board too was not really good. And The teacher talks too fast while teaching. This affects students mathematics understanding There is the used of phrasal expression during he's classroom practice.*	
Moderator	*What do you mean?*	
Jackson	*I mean he sometimes start a sentence without really completing it, it affects students sometime as they don't really know what the teacher means.*	
Moderator	*Any other problem observed in his classroom teaching?*	
Jackson	*Yes, there is this issue of raising or using other languages while teaching.*	
Moderator	*What do you mean*	
Jackson	*I mean ... this is not in terms of trying to explain something clearly to the students in the way they will understand but is like speaking and saying things like you hear Ba?*	
Jerry	*Do you mean speech mannerism?*	

Jackson	*Ohmmmmmm. That is it.*	
Moderator	*While that is normal to some people, if that will make students to follow and understand the concept you are trying to pass across, I don't thing that is a problem. Even the English people have their language mannerism sometimes they will speak them to you. For instance if they want to say I want to do this or that they will say I wanna do this or that. So let us try to avoid that but if we can there is nothing we can do.*	
Moderator	*What about Jennie is there any problem in the classroom practice of Jimmy*	
Jennie	*There is this problem he had , when he was explaining some steps for example in the case of an equation*	
	Q – 8 = 0 or P – 3 = 0 *Instead of saying add 8 to both sides, he said we should just move 8 to the other side without proper explanation to the students why we are moving 8 to the other side. That is --- what am saying sir, is that he did not explain the operations going on to the students during he's mathematics classroom practice*	
Moderator	*The issue of the equation Jennie talk about, a good mathematics teacher is not supposed to say let us carry this to the other sides, but rather there are some mathematics languages that he is supposed to use.*	
Jerry	*Yes sir he is supposed to use the following mathematics expression depending on the equation of the number he wants to move to the other side. Divide both sides by 8, multiply both sides by 8, subtract both sides by 8 and or add 8 to both sides.*	
Jennie	*He did not really make application of the various elements of Intellectual Quality in he's classroom practice. He's teaching was mostly teacher centre as he was doing most of the talking. The other problems observed from he's classroom practice includes there was lower order thinking, as the teacher did not really give the study challenging problems to allow them the opportunity to use thinking abilities., as my colleague said he made incomplete sentence in-betweens he classroom practice, which involves frequent missing of languages, he's steps were inconclusive also. Though there was deep knowledge as it was partially stated but because of he's inconclusive sentence I don't think there did real deep understanding among the students there understand was also shallow. He knew what he wanted the students to know but lacks the pedagogical strategies to make them learn it well*	
Moderator	*Is there any other problem with Jimmy classroom practice*	

	Jerry?	
Jerry	*I think Jackson and Jennie have said it all. But let me just mention these observation because of time. There was lower order thinking among the students because they students were not really motivated to think and use their intellectual abilities in the lesson this is because the lesson was more of teacher centre. There was some such of knowledge as problematic, because intermittently you really see the students the students talking and discussing the problem, however it looks like substantive conversation but let me just say its knowledge as problematic. There was knowledge but no too deep hence understanding of the students was just based on what the teacher give them. There was no much student's self-generated knowledge all the knowledge they got was from the teacher.*	
Moderator	***What possible suggestions can you make to help him improve in the next cycle?***	
Jackson	*He should just adjust, and improve in the mastery of he's mathematics language and used more time to study and evaluate all that we have said here.*	
Moderator	*Each researcher please should study he's elements very well and study how these elements could be implemented in he's classroom practice because that is what we are actually doing the implementation of the various elements in the four dimension of Productive Pedagogies in our mathematics classroom practice.*	
Jerry	*Sir, there are bound to be some lapses in the implementation of all of us, because this is the first time we are knowing this concept of Productive Pedagogies and hence in its implementation there are bound to be some lapses, I think as we grow from cycle to cycle we shall developed some more stamina to do well*	
Moderator	*Yes it's normal and that is why we are looking at the first research objective the growth in understanding and implementation of the Productive Pedagogies in reforming mathematics classroom practice. But we have to study harder since according you we are meeting the Productive Pedagogies concept for the first time as in-service teachers.*	
Moderator	***Are there areas Jimmy showed some strength in his implementation of Intellectual Quality?***	
Jackson	*Yes sir, there were a lot of strength, though he started slowly and was working alone, but as he continued he developed some confidence and get the students involved in what he was doing. So to some extent there was a bit of substantive conversation but mainly between the teacher and the student. This was observed as a student begins to contribute to the solution of the problem that he was solving.*	
Moderator	*Jerry is that true? Where there some strength in Ar1*	

	growth in understanding?	
Jerry	*Yes sir, some of the strength. However they are majorly what Jackson said. However, there was a bit of Knowledge as problematic in he's work; the researcher really had the deep knowledge he wanted the student to know but There was only the problem of how to present he's knowledge to the understanding of the students.*	
Moderator	*Saying what others have said does not really mean repetition but rather a confirmation that the same observation was made.*	

2. Focus Group Meeting Sample Discussion

Speaker	***Comment Made***	***Coding***
Moderator	*In this section we shall be discussing the effect of Productive Pedagogies in our classroom engagement*	
Students	*Ok sir*	
Moderator	*So what is the effect of Productive Pedagogies in our mathematics classroom practice?*	
Micah	*Sir, for this lady now teaching mathematics in my class, students really like mathematics now especially the way she uses Productive Pedagogies in reforming her mathematics classroom practice.*	
Jane	*Yes that is true sir,*	
Micah	*It's like fund now learning mathematics using Productive Pedagogies unlike before that mathematics looks like a monster. Productive Pedagogies model for classroom practice makes teaching learning easier and students' friendly.*	
Moderator	*Is that so?*	
Micah	*Yes sir, if Productive Pedagogies should be introduced as a model of mathematics classroom practice in our schools, the rate at which students fail SSCE in mathematics will reduce drastically.*	
Moderator	*Does Janet have something to add?*	
Janet	*Yes sir,*	
Moderator	*Ok let us hear your contribution.*	
Janet	*Thank you sir, I think having a female teacher teaching mathematics will help encourage the female students going into mathematics and mathematics related courses*	
Moderator	*Thanks you Janet*	
Janet	*Sir, with this, it's like Productive Pedagogies, helps in creating unity among students in the class, which brings*	

	about excellent cooperation between students and students and between teachers and students also.	
Michael	*That is true Janet, and also Productive Pedagogies add more to students understanding to mathematics in a particular topic, than the other normal mathematics classroom practice where the mathematics teacher will just come and be talking…*	
Janet	*You even find it difficult to understand what he is saying and you cannot talk. But here the teachers are friendly and you also have your classmates to interact with in areas you don't understand.*	
Julie	*That is true and in fact it brings about good relationship between students and their teachers during mathematics classroom practice.*	
Michael	*With Productive Pedagogies as a model for classroom practice students finds it easy solving mathematics during classroom activities because we have friend that could put you through if you are lost out.*	
Moderator	*Can we listen to Julie*	
Julie	*Thanks you sir, if Productive Pedagogies in introduce as a classroom model in our schools mathematics classroom practice, every students will feel included as part of the mathematics classroom.*	
Moderator	*How Julie can you explain further?*	
Julie	*The slow learners will be carried along and there is interaction between students and students and between teachers and teachers no one feel I know it more than you*	
Moderator	*Now Jane you wanted to say something*	
Jane	*Yes sir,*	
Moderator	*Then go ahead*	
Jane	*The sitting posture created by the mathematics teachers during their mathematics classroom, practice, tents to encourage slow learners.*	
Moderator	*How? What do you mean?*	
Jane	*We were fix to sit in groups like in a circular form, and we were made to interact with one another in the class, that encourage the slow learners and they were not left out they were carried along.*	
Moderator	*That is good*	
Jane	*When the cultural background of the students is respected, it tends to make the students feel included in the mathematics classroom practice.*	
Moderator	*That is also good any other think you want to mention?*	
Jane	*No sir, that is all*	

Moderator	*Mike what is on your mine? Do you have to something to add to what Jane had said?*	
Mike	*Yes sir,*	
Moderator	*That is good*	
Mike	*If Productive Pedagogies is to be used in our schools, Nigerian schools will improved in support, between students and students and between students and teachers and even between teachers and teachers also.*	
Julie	*Sir, when the cultural background of the students is respected, students tend to a kind of feel included in the mathematics classroom practice and none is left out.*	

APPENDIX 8
SOME SELECTED CODES

1: Some Selected Codes from the Workshop.

Jackson: Students' readiness to learn, and the time a teacher has at his disposal determine his approach or method use. Because if the class is too large or you don't have time, the best thing the teacher can do is to simply teach and work away. That is using the traditional lecture method and gives them classwork

Jerry: The problems mathematics teachers have in their classroom include their self-centredness. That is when most mathematics activities given in the class are teachers centred and not student-centred. It makes teaching learning in the class difficult for the students.

Jimmy: Mathematics teachers don't allow students participate in the problem solving in the class. They do all the talking and students' contribution is not regarded; they sometimes don't allow students to asked questions in the class.

James: Yes, that one is being done. But there are students if there is no pain there will be no gain and the idea of productive pedagogies is to carry everybody along whether slow learners or the gifted ones. So in order to carry them along and make sure they participated in the classroom activities, we have to cause them some pains to get the best out of them. You know there are some students that are best identified through this.

Jennie: Sir truly based on our African cultural context; I will say there is nothing wrong with the use of cane, but what we are saying here is that it should not control the class. However as mathematics teachers, I feel we should inculcate in students self-discipline. We talked about self-regulation, why not teach the students to be self-discipline instead of using cane? It all depends on the way teachers approach it. I think I have learnt that this self-regulation is good for our students instead of carrying cane about.

2: Some Selected Codes from the Planning and Reflection Meetings

Jerry : He allow the students to battle with the question and come up with their solution, there was a lot of substantive conversation between the students and they were seen working together asking questions from one another in order to get the direction to the problem raise in the class. So I can say based on what happen above there was higher order thinking and there was substantive conversation between students as against self-centred approach seen in cycle one where it was only the teacher talking with little of teacher student conversation.

Jackson: Sir, he got the students working on their own, and in groups, he was only moving around to see what the students were doing and offer helps where necessary. The problem was so challenging that the students had to use their background knowledge and knowledge integration. For example, from the question given to the student which was beyond their abilities, I observed in one of the groups they had to use their knowledge of surd in order to really bring out the solution of the quadratic equation they were solving. Without this the students would have found it difficult to crack the difficult and the highly *intellectual quality question given to them. This demonstrated that Jimmy improved in cycle two.*

Jennie: When a mathematics teacher runs into problem of having a large class to manage…, productive pedagogies framework is the best…, it will help in students' classroom control, since learning is in group, the group leaders take charge of their groups…, and you will discover that interactivity and collaboration will be going on in the groups. All the elements of the entire dimensions will just be exhibited within the group…; the social support, the substantive conversation …, I think to me…, is the best strategy for handling large classroom problems.

3: Some Selected Codes from the Focus Group Meetings

Micah: There was cultural integration in the class, the grouping where not based on tribe or religion, the students were scattered to sit with other students not based on the fact that this is my friend or not my friend…, The teachers knew what they were doing …, they were able to make sure everybody was involved…,

Janet: The mathematics teacher recognises the presence of females' students during their classroom teaching…, not that the boys was neglected…, but because the participating teachers recognize that we females' students sometimes feels mathematics is for boys and not girls'…., As it is generally believed that boys are usually regarded as mathematics GURUS…, while everybody believed that girls are always left behind in…, But the teachers made us to understand that it is not true we females can do it also and even better, so we were encouraged…, similarly, seeing a female mathematics teacher among the teams teaching mathematics also made a world of encouragement in the part of the girls in the class.

Jane: there was good classroom participation… every member of the class participated…, the teacher always asked students to solve problems on the board instead of him doing (Solving) it for them, the students were doing most of the work and he (only) assist when he discover that the students are hook-up. I think these aid students understanding better than when the teacher is doing all the work.

Michael: The teacher write the question on the board and ask us to solved it in groups first, before going to the board to solve it for the class, that is, to some extend he allow the student to try the problem first before he solve it for them on the board.

Julie: this is not only you alone thinking on how to solve a particular problem, the thinking is in group, by the time we join our heads together and think on a solution to a particular mathematics problem, you bring your idea… I bring my idea…, the solution becomes easier

Mike: When the teacher was teaching, he gave us a question to solve, and that question was "firebulous" (meaning too tough), we had to think…; think…; and think…; in our groups before we were able to come up with the clue of what to do.

4: Some Selected Codes from the Casual Interviews

Jackson: The way the program was structured emphasises very challenging learning objectives, we received and provided support to one another, and not only is feedback given throughout the program but we actively sought for it, not only from the researcher, but also from colleagues.

Jerry: There were certain things I did which demonstrated connectedness…, I asked my students to identify different shapes they could find in the class. The students were interested and happy to see mathematics relating to things around them…, they identified rectangles, triangles and squares using the chalk board, their desks and many other different shapes found in the class. This made my teaching real and practical it also attracted my students' interest and participation

Jimmy: I observed in my class that my students began to feel that arriving at a particular solution to any mathematics problem is not the issue…; the main issue is their understanding of how and why such solution were gotten…,

Jerry: When we got to the class, we discovered that the students were sitting according to their identities- boys with boys; girls with girls- even among these students we discovered we had another problem, students from the same tribe or culture sits together and you find them interacting in their own language. Therefore the only thing we did was to reorganize the class with the help of the mathematics teacher.

Jackson: Students need a lot of substantive conversation to solve highly Intellectual Quality problems that required higher order thinking, deep understanding and knowledge as problematic especially when highly Intellectual Quality problems are given

5: Some Selected codes from the Research Journals

I entered Jerry's class…, it was his second lesson with his senior secondary one students. Jerry wanted to introduce the concept of perimeter of regular and irregular shapes to his students. In introducing his lesson, he started by revising what he taught in the previous class which is the identification of different shapes. He then when further to create and activity where he brought four students and asked them to stand at the four angles of the class. He gave the first students an improvised baton and asked the student to run and give the second student, then to the third and then to the fourth student. The students ran round the class and brought back the baton to the teacher.

He then asked the class

Teacher: what where these students doing?

Jamil: They were running a relay race…, but…, what has this to do with mathematics? Curiously asked…,

Teacher: The teacher answered the student then asked…, who can tell me how long did these students ran?

Bosam: It is not possible sir, we have to measure…., or … can we use ruler to measure the distance they covered?

Teacher: you are right we could…, but….

The teacher stopped their, and when further to ask more questions and the students responded positively, from the questions he asked lead to the topic perimeter. The students through self-discovery were able to see perimeter as the distance round a given shape…, He further sketched the shape of the class showing the four students at different points in the shape. From my observation I expected Jerry to ask the students to use either their feet or the metre ruler that was in the class to measure the distance each of the students ran, but even though he did not used that he did something similar, he asked the students to estimate the length in metres each of the students ran. The students looked at the difference distances each of the students ran and suggested the distances covered by each of the students (Research Journal: 2013)

I stood at the window of the class and observed what Jennie was teaching. Her topic was "Revision on Sequence". She initiated and activity that involved questions and answers techniques between her and her students. She started by saying…,

Teacher: what is a sequence?

Jane: Sequences are numbers that are arranged with specific patterns or intervals with specific rules guiding them

Teacher: That is good; sequences most have a uniform pattern or rules guiding them. Can we mention some events we know that are sequential in our community or that suggest the idea of sequence as define by Jane? Remember it most have a pattern and there must be a rule guiding it.

Julius: Eating of food is in a form of a sequence.

Teacher: Can you explain the pattern and the rule guiding it?

Julius: When you eat let say 7am in the morning, you may not eat until 12noom then 7pm that is a sequence.

Jennifer: I don't think the idea of Julius is correct…, that is not a sequence…, people eat at different interval. There is no rule guiding our eating;

Teacher: Ok who then can give a better example?

Jeremy: changes in age:

Teacher: give us the interval or pattern and the guiding rule.

Jeremy: If I and my friend were born the same day, the following year we will both increase by one year. Also all changes in our body are changing in the same pattern

Jonah: No…… it's not possible the rule does not always follow…,two people could be born the same day one is tall and another is short…, supposing you were born the same day with a girl…, (laugh)…, changes in your body and hers are not the same…, for example…., (laugh…, the whole class also laugh along)….,

Teacher: The increase in the number of years could be seen as sequence but in terms of growth and development the pattern does not always follow that is true Jonah.