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AN EXAMINATION OF THE PLACE OF SCHOOL MATHEMATICS IN PREPARING PUPILS FOR THE WORKPLACE IN ANTIGUA AND BARBUDA

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University of Nottingham for the degree of Doctor of Philosophy

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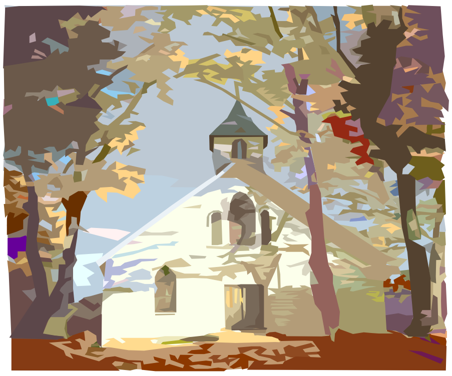
Dedication

Dedicated to the loving memory of my Father

For whom the greatest gift on earth was knowledge

And

To the lasting memory of my mother



Who taught me how to pray for that knowledge

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Here at the University of Nottingham, thanks to my supervisors. Peter Gates, you have been my source of strength and source of energy when the times were difficult. Thanks for the stupendous demonstration of your first class role as a supervisor. Anne Convery, thanks for your professional eyes for detail, the meticulous manner in which several chapters of this thesis were addressed and your supervisory role during my first year in the programme. Tony Fisher, thanks for your love, passion and dedication for your supervisor's role. Thanks for the energy you brought to the journey, just as I was beginning to falter. You were indeed the wind beneath my wings.

To my Caribbean brothers and sisters, there would have been no sunshine in my heart without you. Through it all, only God's mercy was good enough for me. Thanks to the Christian brothers and sisters who made this possible. To the entire Weston dynasty, I am just the messenger. This was a race ran by all of us. God bless and let us continue to serve a needy world with love, respect, knowledge and wisdom.

Abstract

This research examines the preparation made to enable mathematics teachers to appropriately prepare school leavers entering directly into the workforce upon graduation to handle the different branches of mathematics. The methodology was that of the interpretive qualitative paradigm. The method was that of the multi-method case study and the tools included: constructed conversation; interviews; telephone calls; email; focus group; photography; video recording; participatory observation; observation and documentation. The theoretical framework was informed by components of the Engeström (2001) second generation model.

The study found that while there was hardly any preparation made in the system to accommodate mathematics teachers in the appropriate preparation of students to cope with rapid changes in technology and mathematical skills in the workplace, because of on-the-job training, the newly employed were able to handle the mathematics at their workplaces. Additionally, the technological tools in use at workplaces allowed employees to handle the mathematics in work: complicated algorithms associated with mathematical operations were hidden in these technological tools. Employees were then only required to perform an operation of a push or a pull of a button (switch) to turn on or to turn off the device. Equally, mathematical knowledge at the workplace was an activity; thus there was no need for the pedagogical format required for school mathematics classes. This research is significant since this is the first of its kind in the Caribbean using components of the Engeström (2001) second generation model as its theoretical framework and for examination of the mathematics informing workplaces in

Antigua and Barbuda. It has also served to bridge a gap between school teachers and employers on communication of the different branches of mathematics required in the workplaces of Antigua and Barbuda. Simultaneously it represents a new block in the wall of literature from scholars in the field of workplace mathematics since the Caribbean's space was empty.

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Acronyms and Abbreviations

AAMT	Australian Association of Mathematics Teachers
AG	Acting
ABICE	Antigua and Barbuda Institute of Continuing Education
ABITT	Antigua and Barbuda Institute for Technology and Training
ABNTA	Antigua and Barbuda National Training Agency
ALP	Antigua Labour Party
ASC	Antigua State College
BCME	British Congress for Mathematics Education
BERA	British Education Research Association
BOE	Board of Education
BSA	British Sociological Association
BSRLM	British Society for Research in Literature for Mathematics
Caricom	Caribbean Common Market
CCSLC	Caribbean Certificate of Secondary Level Competence
CDB	Caribbean Development Bank
CDU	Curriculum Development Unit
CECNSP	Caribbean Examination Council�either's New School's Programme
CEE	Common Entrance Examinations
CHAT	Cultural Historical Activity Theory
CPSU	Commonwealth Policy Studies Unit
CSEC	Caribbean Secondary Education Certificate
CXC	Caribbean Examinations Council
CVQ	Caribbean Vocational Qualification
SEC	Eastern Caribbean dollar
EFA	Education For all
GCE	General Certificate of Education
HCK	Horizon Content Knowledge

HTS	Hotel Training School
ICME	International Conference of Mathematics Education
IMF	International Monetary Fund
IPGME	International Psychology Group of Mathematics Educators
JBTE	Joint Board of Teacher Education
KCC	Knowledge of Content and Curriculum
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
MDG	Millennium Development Goal
MKT	Mathematics Knowledge for teaching
MOE	Ministry of Education
NCTM	National Council of Teachers for Mathematics
OECD	Organisation of Economic cooperation development
OECS	Organisation of Eastern Caribbean States
PISA	Programme of International Student Assessment
PLM	Progressive Labour Movement
RIUMIT	Rich Interpretation of Using Mathematics Ideas and Techniques
SBA	School-Based Assessment
SLO	Slow Learners Organisation
SCK	Specialised Content Knowledge
SRA	Social Research Association
TVET	Technical and Vocational Education and Training
UNESCO	United Nation Education, Scientific Cultural Organisation
UPP	United Progressive Party
UWI	University of the West Indies
WB	World Bank
WBR	World Bank Researchers

Chapter 1 - Setting Parameters

1.1 Context

In this first section*,* I focus on setting the parameters. My intention is to ensure that information conveyed explains the purpose of this research, gives information about some of what is written in the field and forecast how I could situate/link my research to what is already in the field. The methodology guiding this research is presented.

In the second section, *my story*, I introduce myself to my readers. Here my socio-economic background is told using the experiences of my mother's and my father's life stories. Simultaneously, I give the reader a chance to understand my world-view and discuss the influence of my family background on my chosen career field. This emphasises my educational journey from primary school to the present.

In the third section, I set out my role as a change agent. This indicates the changes that I see as necessary and the measures that I could use to bring about these changes.

The fourth section outlines the research in its entity: what are my aims; my goals; my objectives and my role as a researcher?

1.2 The study

In recent years in Antigua and Barbuda, there has been a growing concern about the level of mathematical competency exhibited by school leavers. It is the view of many employers in Antigua and Barbuda, that school leavers are not well prepared for the mathematics that they encounter at work (Antigua and Barbuda Labour Commissioner, 2004). Additionally, these employers claim that schools are responsible for ensuring that school leavers are well prepared for the workplace mathematics (Antigua and Barbuda Labour Commissioner, 2004). In contrast, the view of educators is that school leavers are responsible for their own learning (Curriculum Officer, Testing and Evaluation Officer, Principals and Heads of Mathematics Departments, 2009). This research seeks to examine the justification for these claims made by both policy makers and employers.

Previous work in the field by researchers has already established several factors (Naresh, 2008; Williams and Wake, 2007; Bakker, 2010; Hoyles, Evans and Noss, 2009; Zevenbergen, 2010 and Wedege, 2010). One of them is that there is hardly any transferability between workplace mathematics and classroom mathematics (Evans, 2000; Harris and Evans, 1991). In fact, it is the view of some researchers that where this is even possible it is very difficult (Williams and Wake, 2007). Information advanced in the field is that for outsiders to a specific work place at times, it is difficult to see the mathematics in work (Nicols, 2002).

At times it is even difficult for employers themselves to see the mathematics in their work (Bessot and Ridgeway, 2000). Even more astonishingly, some teachers on visits to worksites can experience this difficulty in seeing workplace mathematics whilst for others it results in a rich fulfilling experience (Nicols, 2002; Dowling, 1991; Forman and Steen, 2000; Strasser et al., 2002). However, there are accounts by scholars indicating just how this invisible mathematics can be made visible (Williams and Wake, 2007; Evans 2000; Hoyles et. al, 2010). Elsewhere in the field researchers have concentrated on making transparent the different workplace mathematics requirement which is solely dependent on one’s chosen career (Hoyles, Noss and Pozzi, 2000; Millroy, 1992; Masingila, 1994; Hall and Stevens, 1996; Scribner, 1986; Harris, 1991: Organisation for Economic Co-operation and Development Committee Researchers, 1996; World Bank Researchers, 2007; Committee Members of the United Kingdom’s Advisory Committee for Mathematics Education, 2011).

Although work has already been done in the field from various parts of the world (United Kingdom, Australia, Canada, United States, Germany; Brazil; Netherlands, New Zealand and Denmark), there has been none from a Caribbean perspective, specifically from Antigua and Barbuda. My research, therefore, will add to the knowledge in the field whilst informing policy in my country: a small country (170 square miles and a population of approximately 80,000) (Statistical Department in Census Office, 2008) dependent upon service industries, with tourism playing the major role and with financial services forming the second sector.

This is a qualitative study. My research question is: *Given the increase in technological tools in the labour market in Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the work place?*

The methods of collecting data are interviews, ethnographic observations, constructed conversations, focus groups documentation and photography. The data comprises policy makers, heads of mathematics departments in schools, principals, teachers, employers and employees from different worksites, students and school leavers between the ages of sixteen to thirty. The access to worksites was achieved by employing gatekeepers with affiliation to the sites.

The overall structure of the thesis comprises ten chapters. The first chapter outlines and provides the parameters of the research. It also gives an account of my story and my identity.

The second chapter contextualizes the research. The focus here is the geographical location for the research sites and the system of government and the type of economy informing governance of the country. Additionally an overview and a historical account of the development of the education system are presented.

In Chapter three the literature informing the research is presented.

Chapter four presents the theoretical framework underpinning the research, namely elements of the Engeström's (2001) second generation model of his Cultural Historical Activity Theory (CHAT) tool.

In chapter five, I present the methodology guiding the research. It also embraces the epistemological underpinning of the research.

In chapter six the analysis of the data from teachers' activity system is presented. A focus of the research is embedded in the question *how significant are the resources provided by policy makers to schools in the task of appropriately preparing students for the technological era to handle mathematics that is a part of daily routine in their workplaces*?

A similar format is used in presenting the analysis of the data from the schools in chapter seven. A key focus of the analysis is the question: *How have the mathematical requirements of workplace routines demanded by employers impacted teaching and learning of mathematics in the classroom?*

In chapter eight the analysis is informed by the data from employers. The main focus of the analysis was to ascertain if there was any justification to the employers' claim that the most newly employed were not appropriately prepared from their school's mathematics lessons to handle the mathematics in the jobs at *their* worksites. There is a view among employers that, generally, students who entered directly into the labour force upon graduation from secondary school are not prepared for the job market.

In chapter nine, I discuss the significance of the findings, implications for future practice, areas for further research, and suggestions for the way forward.

In chapter ten, I make projections for the way forward, highlight some of the limitations of this research, the significance of the findings and offer suggestions as to the manner in which some of the suggestions emerging from the data could be accomplished. I also offer suggestions for other areas for research.

1.3 The Problem

In Antigua and Barbuda, mathematics is regarded as one of the core subjects in the school's curriculum; in the secondary schools it is a compulsory subject. The mathematical abilities and potentials of students are only recognised if they are awarded a certificate testifying to attainment of grades 1, 2 or 3 levels in their school leaving Caribbean Examination Council's Mathematics Examination. A student failing to obtain one of these three grades levels would be considered one who cannot do mathematics. This examination takes place at the end of 11 years of compulsory formal education.

This research is important since it comes at a time when governments in the Caribbean, to include Antigua and Barbuda and employers are calling for an educated labour force (World Bank Researchers, 2007); at a time of global crisis in the financial sector of the economies of nations, for example, Greece, United States of America; Turkey (BBC 1, BBC2, 2011) and Antigua and Barbuda (Minister of Finance, 2011) at a time of mass unemployment (30%) (Labour Department Statistical unit, Antigua and Barbuda, 2011) and at a time when educators are demanding alternative forms of assessment (Assistant Director of Education: Curriculum, Antigua and Barbuda, 2011). Its significance lies in the fact that although researchers in the field have addressed social issues of mathematics (George, 2007; Gates, 2001; Nicols, 2006) especially relating to under-achievement in mathematics and studies have examined workplace mathematics in Canada, the Netherlands, Egypt, America and Australia, none have examined this in relation to the Caribbean; specifically not in Antigua and Barbuda. Therefore the value of my research will be judged from its ability to add new knowledge to the already body of existing literature whilst at the same time informing policy in mathematics education in the Antiguan and Barbudan society.

1.4 The Background to the Education System

One of the most significant functions in any society is the education of the young. The prescriptive function of educating the young takes place within specific settings and institutions. The format though is not the same in every society. However, generally, schools exist to perpetuate the epistemologies endemic to that specific society. This is usually referred to as enculturation practices, where the young (children) are inculcated into ways of thinking and behaving commiserate with the norms, culture, and values of their respective indigenous societies.

Therefore, a school does not exist in a vacuum but rather, is governed by certain philosophies and missions specific to the society in which it operates. Nevertheless, countries have been known to adopt their education system from another country and fashion it to meet the demands of their specific society. This is the case in Antigua and Barbuda. As a former British Colony for over three hundred years, Antigua and Barbuda inherited an educational system that was modelled from the British Education system and designed specifically for colonies.

In recent times Antigua and Barbuda government's educational policy has been based on the philosophy that each child should first be socialized as a human being and secondly as an economic unit of production (*Education Act, 2008).* The educational system is expected to develop creative, innovative and adaptable men and women, identify, nurture and cultivate each child's capability, aptitude, skill and strength. To meet this demand, there are thirty three public primary schools and approximately thirty one private primary schools; thirteen secondary schools, eight of which are government owned (Statistical Digest, 2009).

As in any well planned educational system, the Antiguan and Barbudan education system is a systematic preparation for a smooth dovetailing between successive stages. At each level the child is socialised to effect an easy transition. There are four phases: primary, junior secondary, lower secondary and upper secondary. At the end of secondary education students take an external examination prepared by the examination body governing Caribbean schools - The Caribbean Examination Council (CXC). Completion of this examination also signals the end of compulsory formal education, where the minimum age is sixteen years. At the end of this compulsory formal education, school leavers have several trajectories to follow in their choices of career paths. The focus of this research is the trajectory associated with the entrance of school leavers directly into the workplace and their ability to handle the mathematics in their daily job routine.

Once the choice has been made to enter the world of work, employment may then be sought in any one of the sectors of the economy. A study carried out by the former Labour Commissioner (2002) in the Ministry of Labour, as its labour market guide, revealed that of 'the nine hundred (900) school leavers entering the job market annually, approximately two hundred and fifty (250) of these are usually employed in the hotel sector in the areas of water sports, maintenance, housekeeping, bar and kitchen and in guest services. The remainder of the seven hundred and forty employees are divided among the other sectors to include: internet gaming, other private sectors (banking, airlines, general businesses, stores, insurances, restaurants, and agriculture), government ministries and construct*ion'* (Former Labourer Commissioner). From 2004 to the present, the United Progressive Party's (UPP) Government sees itself as only a facilitator of economic growth: 'growth engines to provide good quality jobs, at good wages and salaries at all levels from clerical to managerial to professional advanced by the United Progressive Party Government will come from: tourism, financial services and technology services' (Agenda for Change, 2004, p.10). Hence in light of the government's claim, the sites for this research were drawn from these sectors.

1.5 Mathematics Education

Nicols (2002) claims that Dewey (1916) argued for a study of subject matter through an intertwining of academic and vocational education. 'Education through occupations [not for occupations] consequently combines within itself more of the factors conducive to learning than any other method' (Dewey, 1916, p.309). Dewey (1916) argued for a blurring of the boundaries between academic and vocational education. Grubb (1995) presents eight models or approaches to curriculum integration. One approach, that of making the academic curriculum more vocationally relevant, is referred to as 'applied academics' and has 'become the most common approach to integration' (Grubb, 1995, p.69). The consensus is that applied academics courses designed to provide students with workplace relevance have promise; students learn mathematics in the process of searching for solutions to meaningful work-related problems.

This is in contrast to typical situations where students are asked to show their understanding of mathematics through application problems located at the end of the chapter (Threlfal, 2002). It has been claimed that the union of mathematics, work and school provides pedagogical possibilities for helping students become mathematically literate: to be prepared for open, unstructured problems; to understand the mathematical features of problems; to solve problems and to analyse data; and to work with others (Hoachlander, 1997; Packer, 1997; Pollak, 1997). This is my hope, to give purpose to the learning and teaching of mathematics in Antigua and Barbuda.

Helping students connect mathematics to real life and work relies to some extent on the experiences of teachers. Hence teachers should not be forgotten, invisible participants. Therefore, my research embraces teachers, not as passive onlookers but rather as participatory observers. Researchers such as Resnick (1987) point to differences in learning that occur in school and out of school contexts suggesting that traditional school learning is limited in preparing students for out of school activities. It is felt that teachers who come to mathematics teaching with experiences of doing mathematics in out of school contexts such as hobbies, recreation, or work have opportunities to draw upon these experiences in designing problems for students.

A great deal of research supports the relationships between the subject matter understandings of teachers and the pedagogical opportunities they may be able to offer their students (Ball, 1990; Ma, 1999). I have benefited from my mathematics lessons in which my teachers were indeed tradesmen firstly and later through a change of career path had become academicians.

This is a practice on-going in developed and developing countries. For example in 2004, from January to March, I was a student at the Tamarani, Overseas Teachers Training College for Higher Education, in Chennai, India. It was amazing to be told that all of those male lecturers now engaged in curriculum training exercises were trained as engineers, attaining doctoral status. They too made an impact on my understanding of how academic and the real world of work should merge to bring meaning and purpose to classroom teaching of mathematics, thus preparing students for the world of work. That is why this framework is so important to my research since personally, I have experienced the value of having teachers who come to mathematics teaching with experiences of 'doing' mathematics in out of school contexts; the joy they brought into learning classroom mathematics using their vocational backgrounds to inform pedagogy whilst ensuring not only to teach their subjects but also to teach the subjects (Barnette, 2007).

Therefore, if teachers are to help make the study of mathematics connected and relevant to students' lives they too need opportunities to experience connected and relevant mathematics. Furthermore, if they are to facilitate opportunities for educational change then they need opportunities to extend their networks of practice which are typically subject-based to include industry and labour partnerships.

Before launching this research, it is time to meet the author.

1.6 My Story

Who is Caron O Weston? What accounts for the outlook and the philosophy she has on life? What economic circumstances were responsible for the trajectory of her career? What roles did her mother and father play in this? What is her experience of living in a family? What is her relationship with her fellow countrymen?

In this section I present my story using the following headings: (i) socio-economic background and impact of the economy; (ii) my early life and primary education; (iii) my secondary education; (iv) my career and the economy of Antigua and Barbuda; (v) the existing conditions; (vi) reflection on my work and (vii) role of the mathematics officer.

1.6.1 My Early Life and Primary Education

The family unit that provided me with loving, caring, conducive environment any child would have been proud to call home comprised ten children: six girls and four boys. I was the sixth child. I therefore had three older brothers, two older sisters, three younger sisters and a young brother.

My father spared no effort in ensuring that this household was governed by a culture of academic excellence. He had a good and capable partner in his wife Estella. Together, they marshalled the little army of children, directing the path and progress of intellectual growth both socially and cognitively. Edmund was playing the pipe and we were marching to the rhythm and the tune.

Edmund was a farmer and a fisherman by profession. Despite this he was careful in shielding his children from these two professions. Nationally they were considered as menial professions or non-professions at most. The island's history from slavery could be conceived as responsible for this mentality. Therefore, as children, we were never permitted to go to the Bay side to collect the fish for dinner out of his day's catch. If my mother could not go to collect them, they would have to wait until my father was coming home. Our Bay side visits were for swimming or going with him on a boat trip.

For similar reasons, we were not allowed to help on his agricultural plot: to engage in weeding or caring for his crops of cabbages, onions, tomatoes, ochroes or corn grass; ground provisions of sweet potatoes, yams, cassavas and eddoes. Our visits only were to help in bringing home the produce in preparation for marketing. Our main focus was the academic path. He ensured this silently and conscientiously. All his children from the union became academically competent. All ten of us went on to win scholarships to secondary educational institutes.

1.6.2 My Secondary Education

For me, secondary education began in 1966, when in the January of that year I won a scholarship to the privately owned Sunnyside International School. This school was stigmatised locally in some quarters especially amongst members of the lower class of society.

In Antigua and Barbuda at that time, as a colony of England, with the internal and external affairs of the country being controlled by England, most of the managerial and top positions were held by white expatriates. Of the approximately two hundred students in the school, only eight were nationals of Antigua and Barbuda parentage. Seemingly overnight the world had been reduced to a microcosm of a global village. It was a culture of learning and playing, where tolerance for differences in opinion was encouraged. Daily we grew to live with each other. This was really my first experience of a *bring and share lunch*; it was an exciting time. The teachers were in the main also expatriates from all of these countries.

Whereas in my primary school the focus of the mathematics lesson was mainly on arithmetic in my secondary school geometry and algebra were added. I was a good mathematics student. My foundation from the primary school years of mathematics was solid; and my teachers here at Sunnyside appeared familiar with what they were teaching: pedagogic skills were excellent. Independent learning and peer teaching were encouraged. Individual pace setting was also present. All these strategies, together with whole class conventional teaching underlay my classroom mathematics lessons. On several occasions I had been engaged with tutoring during the breaks. Competent, motivated and well trained teachers, in the art of teaching and learning of mathematics, ensured that at the end of secondary education, mathematics was my favourite subject.

The curriculum used throughout my secondary education in mathematics was the one adopted from England's Westminster style General Certificate of Education (GCE). History will show that secondary education in Antigua and Barbuda was started by the Anglican church, especially the all-male Grammar school (Archdeacon Branch) and the All Girls High School, (sister Mamie Branch) specifically to cater for the children of the expatriate colonial masters, always with the hope of sending them back to their homelands for higher education. The local students who attended the grammar school were few in number as it was by scholarship only – a maximum of four annually for each school. The national students also had to be legitimate children.

Thus the General Certificate of Education Curriculum was not one that focused on the local economy of Antigua and Barbuda but rather one that was devised with academicism in mind. It was never skill based. My 'A' level courses only helped to compound this desire for the academic way of life. Here my main focus was for a university degree leading to the Bachelor of Science in Mathematics. This focus was in response to the nation's demand for mathematics teachers.

Thus, although the main focus using the General Certificate Education curriculum was academic in nature and knowledge based, it had its advantage. The previous Seventh Standard Education and therefore its curriculum did not provide the state with too many of the cadre of professionals needed to manage key areas of the economy, even within its monoculture status. Hence the many scholars using this as background for university and higher degrees justified its usefulness. Nevertheless, the masses had to be catered for. During the late nineteen seventies with the churches no longer able to support the upkeep of education financially, the government was in control of the Grammar and High schools. By nineteen hundred and seventy nine the economy of Antigua and Barbuda had changed to a service based tourist economy.

The, then General Certificate of Education Curriculum, was replaced by the Caribbean Examination Council to meet the change in demands of the labour force. Previously, there had been a need for unskilled labour; the need now was for a skilled labour force. Additionally, with independence came the exodus of expatriates holding top managerial positions. These positions now had to be filled by nationals. It was also a time when many nationals having completed degrees at external universities (Europe, North and South America, University of the West Indies (UWI), University of Guyana, University of the Virgin Islands and Puerto Rico and Cuba) were returning.

Thus positions to be filled by professionals and skilled labourers included: doctors; nurses; lawyers; bankers; town and country planners; meteorologists; air traffic controllers; masons; carpenters; engineers; teachers both secondary and primary schools; contractors; hoteliers; tourist guides; economists; heavy duty motor vehicle operators; masons; chauffeurs; taxi drivers; custom officers; emigration officers; mechanics and others spreading across the entire spectrum of skills based and professional fields (Former Minister of Tourism and the Economy, 1976).

The focus of the curriculum now was that of providing the labour force with educated workers. The mathematics taught in schools should now be relevant and seen to be performing the task of preparing the students for the work force. I had just returned from the University of the West Indies and took up an appointment as the Head of Mathematics Department in one of the secondary schools on the island of Antigua.

1.6.3 My Career and the Economy of Antigua and Barbuda

The new Caribbean Examination Council's syllabus was the one that was used in my classroom practices, whilst I was in my position as a professional graduate mathematics teacher. When I graduated in 1979 from the University of the West Indies (U.W.I) the economy of Antigua and Barbuda had transformed some four years ago to a service based economy with the engine of growth as tourism. Unskilled workers were no longer the main core of the work force. The diversity in the requirement of workers for the job market, created by the tourism industry, demanded a labour force to reflect this. For with the tourist industry the need for a multiplicity of requirements in all sectors of the economy was clear. For example, there was the need for infrastructure to meet the growing demand for rooms to meet a growing demand for rooms to house the tourists' population.

Therefore, the sector of the labour force requiring the most urgent attention was the construction and building sector. Hence there was the need for carpenters, plumbers, electricians, accountants, heavy duty operators, machine operators, housekeepers, accountants, receptionists, gardeners, restaurateurs, taxi drivers, curators, museum operators and many other managers for local cottage industries. There was also the necessity for trained country planners and environmentalists to ensure that the boom in the building industry would not have a negative impact on the environment. With all this change in the economy the necessity was greater for the mathematics curriculum to provide students with knowledge which could be allegedly transferred to the workplace.

Therefore, if the education system had as one of its key functions to provide the foundation for young people to become ready to transfer to the labour market it would need to be relevant and appropriate. Thus the mathematics demanded to train and equip the students in my classroom, should provide them with the knowledge base required for problem solving, reasoning and logic; leading to the cultivation and development of sound judgements in solving and coping with workplace mathematics.

The relationship between workplace mathematics and classroom mathematics, was not part of my practice throughout my first year in the classroom (1979- 1980). My chief concern then was to acquaint myself with the new topics that were part of the Caribbean Examination Council's syllabus. As a classroom teacher, I became part of a profession whose culture was interested in getting students to gain a passing grade in mathematics. Preparation for this feat however entailed my imparting some of the delights and pleasures in this subject. Completing the topics on the syllabus by the most efficient method and motivating students were central to the mathematics experience I wanted to share with them. However, linking mathematics to the economy of the day was not a part of my world. Merely preparing students for passing the examinations were my concerns.

When I took up the post as Mathematics Officer on 23rd February 2000, what I inherited was a culture of mathematics education characterized by a majority of untrained teachers. These untrained teachers taught just as they had been taught - rote and recitation. The method of teaching by question and answer made it possible for pupils to seem to have learned a great many important facts, but the real fact was that pupils did not understand the memorized facts (Orton and Orton, 2002; Gates, 2004). This came to the front where students were administered mental mathematics questions involving basic concepts of topics that I taught in my mathematics lessons. The performances were always very poor. Today, not much has changed in this area, as perceived by performances of students in the annual multiple choice mental mathematics papers from the Common Entrance 11+ years Examinations and the Caribbean Examination Council's statistical records of its multiple choice examinations over the years, (1979-2011).

Contrary to the belief that facts were understood by students during mathematics lessons, Tanner and Tanner's (1995) explanation has provided plausible suggestions for the phenomenon where teachers could be led to believe that learning had taken place by pupils for taught mathematical concepts when in fact the opposite was the case. The claim was that students connected the question and its answer with some outside association and they were able to parrot rules and formulae with verbal accuracy, thus impressing and delighting those to whom the words had a meaning. However, a more thorough examination showed 'their meaning for the pupils to be as much a mystery as the hocus pocus of a magician' (Tanner and Tanner, 1995, p.65). The resonance here, the fact that Tanner and Tanner (1995) have a commonality of this type of experience with me would seemingly indicate that this is not only an Antiguan and Barbudan problem but rather a global problem.

The inheritance package also included: teachers with a lack of subject content; dull boring manner of teaching mathematics topics; lack of creativity; fear of mathematical concepts by individual teachers; teachers' anxiety caused by fear of failure; working in isolation in separate classrooms; poor self-esteem and a package where students hated the subject. In fact, this was a time when mathematics was a daily experience of continued failure and irrelevance. Mathematics education failed too many children; 'it failed children on the margins of society; it failed children from ethnic minorities; it failed children from social and cultural backgrounds that are different from the majority of mathematics teachers' (Gates, 2000, p.7).

These very same conditions are the ones that have influenced my position as Antigua and Barbuda Mathematics Officer to introduce a more progressive and learner-friendly environment whilst dealing with mathematics education in the nation of Antigua and Barbuda. And all this came against a background where Fullan (1991) reported that historically over the past thirty years there have been four periods of an education era. Today we are living in an era, where globally the call is for a change in educational practices, fuelled by the new and rapid increase in knowledge brought about by the technology at student's disposal.

1.7 Role of the Mathematics Officer

As the mathematics officer of Antigua and Barbuda, I was directly responsible for ensuring that the mathematics curriculum as mandated by the Antigua and Barbuda Government was delivered at the relevant levels across the school system. The job also involved direct supervision of all teachers of mathematics in the system. Thus, the fact that there are weaknesses associated with the way mathematics is being taught and learned becomes another of the roles for me to address, with the view of finding suggestions.

The role of the mathematics officer of Antigua and Barbuda involved not only working with a specific set of students in one secondary school but rather an examination of the role of mathematics in the life of every student in the educational system. It also involved an examination of the teachers' roles in their professional approach to classroom practices, of teaching strategies, content knowledge and the schools' cultures.

This opened up a larger view and the territorial area that I needed to traverse in my practice also got wider. For the first time the question I had to ask myself was: what should we be doing when we are teaching mathematics? This was the question that initiated my examination of the way in which mathematics was being taught, and to conclude that it was imperative that the way in which mathematics was taught and learned in the classroom should be changed. Nevertheless, I have not been able to answer one of the questions intuitively. This is the question that asks: is the mathematics curriculum used in the secondary schools of Antigua and Barbuda preparing school leavers for the workplace?

1.7.1 Influences on My Work as a Researcher

Proclaiming that schools should supply society with the educated labour force needed for this knowledge-based economy in which my students will live out their lives, also places a responsibility upon me as leader of teachers in mathematics to ensure that the content of the subject is indeed fulfilling this mandate.

It is conventional, almost a ritual for me to prepare students for the school leaving mathematics examination with the aim of students gaining a pass. However, can I truthfully conclude that passing the examination has adequately prepared students for workplace mathematics? Were we focusing on certification rather than preparation for the workplace? What of those students who did not pass the mathematics examinations? Are they prepared nevertheless for a place in the market? What in fact are the demands of workplace mathematics? Is a transfer from classroom mathematics to workplace mathematics feasible? These are questions that cannot be answered without systematic research.

Additionally, how can I as the Mathematics Officer know what mathematics was required in specific worksites? How can I begin to construct any contingency table to map out the foci the mathematics education should be taking? At this time in global history, when economies of India and China are becoming more significant, and Europe and America are experiencing a downturn in their economies, when in Antigua and Barbuda the unemployment rate is 30%, (Labour Department, 2011) with the rate being highest among the youth. More worryingly the national pass rate in the annual end of year Caribbean Examination Council's School leavers' Mathematics Examination was 29% (Caribbean Examination Council's Statistics, 2011). At this juncture, this research will be important in providing suggestions for policy makers, as they make decisions to govern the mathematics programme in the state.

1.8 The Research

In this section I describe my research using several subheadings: (i) purposes; (ii) methodology; (iii) methods and (iv) researcher's reflections. These subheadings provided the basis of the information in this section. My research draws on conversations with participants in four workplaces in order to answer key questions underpinning my main research question:

> *Given the increase in technological tools in the labour market in Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in workplaces?*

Subsidiary questions are:

> *Is the mathematics taught in the secondary schools of Antigua and Barbuda by mathematics teachers appropriately preparing school leavers to handle the mathematics in the job market?*

> *What is the impact of employers' mathematical needs on mathematics education in secondary schools of Antigua and Barbuda?*

All research is motivated and has values and politics embedded in the assumptions from which it starts. These values and politics are not always made explicit and possibly not even noticed. My starting point is to learn more about the kinds of mathematical skills needed and used in workplace settings in Antigua and Barbuda.

My first objective is to identify and describe mathematics in labour market functions and to analyse how mathematics knowledge at work is interwoven with the worker's classroom mathematical qualification.

My research sites include the Ministries of Education, six secondary government schools, hotels, customs departments and a private utility service enterprise.

Relevant gatekeepers helped me to gain access to research sites.

1.8.1 Methods

The methods I use comprise ethnographic observation, interviews, photography, informal conversation, focus group discussions and documentation analysis. I chose to use a qualitative approach because I am seeking to build knowledge whilst addressing social and economic issues. I will also be 'visiting, observing and discussing with workers and so identifying at least one (usually several) practices of some mathematical interest to them' (Williams and Wake, 2007, p. 318).

Additionally, since this is a qualitative research and the 'focus of a qualitative study is initially broad and open ended, allowing for important meanings to be discovered' (Maykut and Morehouse, 1997, p.43), the eight characteristics affiliated with all qualitative research will be adopted in this research.

1.8.2 Researcher's Reflection

In reviewing and analysing the literature of mathematics at work it has become apparent to me that there is neither unitary work mathematics nor unitary school mathematics. Some professions place varied mathematical demands upon workers. Work provides challenges and opportunities for people to develop mathematical knowledge which is meaningful (Carraher, 1988). It is my view that in studying how people come to make sense of mathematical ideas outside of school, I could learn how to promote this transition, making meaningful representations and procedures more powerful on the one hand, and making powerful representations and procedures psychologically meaningful.

Arguably, one of the essential arguments coming out of the workplace mathematics literature is that there is no direct correlation between learning of classroom mathematics and the mathematics learned at the workplace. Classroom mathematics is a precursor for attributes needed by employees to cope with gambits of workplace mathematics.

1.9 Summary

In this chapter, I set the parameters to the research, and look at the composition of the research. The significance of this research to the Antiguan and Barbudan society is emphasised. I make suggestions for its contribution to the knowledge in this field of workplace mathematics.

Chapter 2 - The Economy of Antigua and Barbuda

2.1 Overview

In this chapter, I present a historical account of the emergence of the Antiguan and Barbudan economy with its impact on the development of the education trajectory from its colonization in 1492 to the present. The sections will be introduced under the following subheadings: (i) introduction, (ii) economy built on sugar and (iii) summary.

2.2 Introduction

The topography and geography of the island are presented to give readers a perspective of the nature of the site for data collection and insight into the economic activities where school leavers generally sought employment. Simultaneously I highlight the impact upon the content of the school's curriculum and the education system in general, brought about by the changes over different periods in economic activities.

Administration of the economy is discussed and the school's role and its probable impact on providing suggestions for the change in administration of economic activities. I end with the significance of the school's role.

Figure 2.1: Map of Antigua and Barbuda

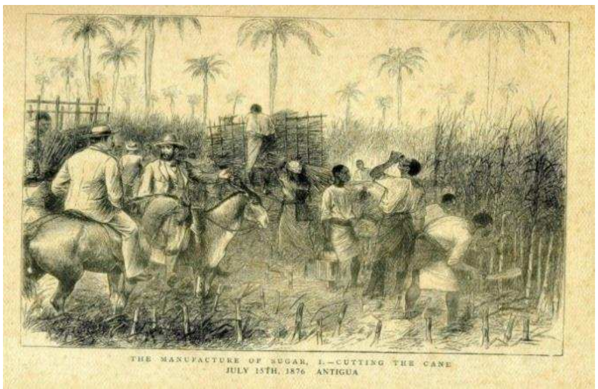
2.3 Economy Built on Sugar

Christopher Columbus, on his second voyage in 1492 named it Santa Maria La Antigua, after his flagship and a church in Seville, Spain. The two islands became a unitary state through legislation enacted in the parliament of Antigua. Today the country is known as *Antigua and Barbuda.*

> *Antigua and Barbuda was colonised specifically as a mercantile resource for the production of sugar. No serious attempts at colonisation took place until 1632 when a party of Englishmen, under the leadership of Edward Warner, set out from nearby St. Kitts and landed on the southern side of Antigua and claimed it for the English Crown (Henry, 2005, p. 48).*

This was the first semblance of economic activity in the embryonic stage of its development as a nation. For the next two hundred years Britain would be the master of the destiny of the welfare of all citizens of Antigua and Barbuda and all economic activities. For the early settlers, it was an agrarian life style. They cultivated cash crops such as tobacco and indigo, cotton and ginger for export and subsistence crops for themselves. In succeeding years sugar came into prominence and the topography of the island would change forever from the engagement in this economic activity. Its production shaped Antigua's landscape to this day when vast areas of rainforest were cleared to make way for sugarcane fields.

Figure 2.2: Natives working on sugar plantation during colonialism



During the seventeenth century, Antigua was one of the most heavily wooded islands in the Eastern Caribbean and its trees were felled to supply timber and spares for ships.

Lignum vitae and other useful plants, which are now largely extinct, were in abundance then (Henry, 2005).

Figure 2.3: Part of the original forest before colonialism (Fig Tree Drive)

In 1674, when sugar was king and Britain ruled the waves, a time when the '*sun never set on the British Empire*' (Gandhi), a dramatic change in the island's economy took place when the first large-scale sugar plantation was established by Sir Christopher Codrington from Barbados. His success encouraged others to turn to sugar production. More than 150 sugar mills dotted the countryside, many of which are still standing today. The early planters christened many of their large estates with names that are familiar in Antigua today: Byam, Duers, Gunthorpes, Lucas, Parry, Vernon, Cochran and Winthorpe. Workers for the sugar plantations were survivors of the African slave trade cargoes who had survived the inhumane and perilous triangular journey from various ports in Africa, across the Atlantic, to the West Indies (Henry, 2005).

Figure 2.4: he first operation of sugar industry – Bethe's Hope Estate.

As properties of their European Slave Masters they were residents of the various estates. This was a dark period in the journals of the history of Antigua and Barbuda. Life on the island was hard. Slaves worked from dust to dawn for six days of the week.

2.4 Nature of Work During the Colonial Era

In this section I present descriptions of living and working activities during the colonial era. The section is important since it provides the foundation for later analysis in Chapter six, signposting the nature of mathematics informing work at various worksites during this period. The information draws on data from a research performed by Lawrence (2008). Using the tool of face-to-face interviews, the data was collected from former estate workers and the relatives of deceased former estate workers of this era. In her book entitled *Bethesda and Christian Hill, our History & Culture*, the author has argued that 'history no matter how disturbing belongs to us. Let us embrace and cherish it, but most of all, share it' (Lawrence, 2008, p. 145).

To capture the ambience and something of the character that existed in Antigua and Barbuda during the colonial era, Lawrence (2008) interviewed numerous survivors and their relatives of that era. During this period the sugar industry dominated the economy and lives of the majority of Antiguans and Barbudans until its closure in 1972. Subsequent to the 1976 election, there was not only a change in the government but simultaneously a change in economic activities.

Today, economic activities are founded upon a service industry. Therefore, in addition to the ambience and something of the character of the era, this historicity seeks to highlight the nature of mathematics informing work prior to this service industrial era using the structure of a typical sugar plantation as the base. I begin the section by giving an account of the structure of the community informing a typical sugar plantation, more commonly called an *Estate* in Antigua and Barbuda.

2.4.1 Sugar Plantations of the Colonial Era

A typical sugar plantation consisted of a Great House where the proprietor resided. When the proprietor was an absentee owner, generally an attorney or a manager would live there. Relics of great houses on the twin island state would suggest that this dwelling house usually occupied the highest elevation on the plantation. This probably gave the occupants a bird's eye view of the operations on the plantation. To provide further comfort to this way of life, the proprietor had a cadre of waiting men, women, cooks, butlers, and other servants at his command (Lawrence, 2008).

Other structures on the plantation included the manager's house, houses for the overseers, storehouses for grain, stock houses and huts for enslaved workers. The mill and factory buildings were the most important structures on the plantation. They were the centre of economic activities, where enslaved Africans and Creoles turned sugar cane into wealth for the European proprietor (Lawrence and Gordon, 2013). The success of these activities required multi-voiced and a division of workers among the employees. One such group of labourers in this division of workers were the skilled personnel.

Skilled Personnel

The more valued skilled personnel included the carpenters, masons, blacksmiths, coopers, wheelwright, millwright, and boiler man. However, the boiler man who worked directly on sugar production stood out as the most valued slave on the plantation. Planters selected him based upon his skills, his knowledge of sugar cane and how it [should] be handled for maximum output. The boiler man has been equated with 'slave officials', since he was required to have knowledge of how the cane had been raised and treated; the kind of soil in which it grew; whether the soil had been richly or slightly manure; the age of the cane; its species, whether it had been stopped short or long in the cutting, and whether it had been arrowed or rat-eaten.

This information was required to determine what quantity of lime temper (calcium oxide) the cane juice needed and the period required to boil the juice. Thus, the boiler man's skills determined whether the cane would be successfully turned into quality sugar. The procedure for manufacturing quality sugar was not an easy one. It was known as making muscovado sugar. It involved extraction of the juice from the cane stalks by passing them between three rollers powered by animals, wind, or steam engine. The sweet liquid extracted flowed to a boiler, which heated the raw juice, including the scum, and dregs, to a specific temperature.

Subsequently, the juice flowed into a clarifier tank, where workers added tempered lime (calcium oxide) to help separate out impurities. The clarified liquid then flowed down to a wall of coppers, consisting of three to twelve large cast- iron basins called copper tanks. Here the workers had to boil the juice repeatedly to reduce its liquid volume. They ladled the thickening juice into successively smaller, but hotter copper, until the liquid reached the correct consistency. It would then be drained into a trough which carried it down to wooden drying flats to cool and to crystallize, thus producing muscovado sugar.

It takes about a gallon of cane juice to make one pound of sugar. In making this sugar, the boiler man had to know just when the juice reached the correct caramel-like stage for him to strike it. He then allowed it to cool to form crystals.

Workers would then assist in the packing of the crystals into barrels or clay pots to drain for about a month in the curing house rafters. The liquid that drops out of the sugar crystal is called molasses. In the Still House they produced rum from the molasses and the fermented mixture of residue removed during the boiling process.

Other valuable slaves included those most responsible for the livestock needed for ploughing, transporting cane to the mills, and sugar to the warehouses or wharf. Additionally, drivers who worked closely with both fellow slaves and management were accorded a level of respect and importance (Lawrence & Gordon, 2013). Yet another valuable group of workers was the field workers. In the next section, I give an account of their work.

Field Workers

I would argue that proprietors in this colonial era owed much of their prosperity to field slaves. It is my further claim that these field workers constituted the nucleus of the sugar industry. They faced the severest form of work from preparing the soil to plant and to reap cane in the hot Antiguan and Barbudan sun. Their daily work began at sunrise and ended at sunset. They worked in gangs ranging from twenty to sixty members. Their work consisted of digging trenches eight inches deep by approximately 48 inches square. Originally, when planting the canes, cuttings were placed horizontal in the holes. This allowed the shoots to grow up from both ends, thus giving maximum density and productivity. Fertilizers, using animal dung, and carried in baskets by employees, on their heads, were also placed in the holes. This basket of fertilizer could weigh as many as eighty pounds.

Later, there was a change to this method of planting. Planting in rows was the preferred choice, which allowed the cuttings to stand up in small holes. Although a less productive method it was easier to plant, to maintain and to harvest. As the plants grew, women and children weeded and applied cane trash and more dung to shelter and nourish the plants. Stronger men would cut the cane using bill hooks, while others gathered the leaves, known as trash for other uses.

Replanting was not done every year. Instead, the roots, called ratoons, left after harvesting the cane would sprout new crops, but progressively produced smaller and smaller stalks producing less juice. For greatest yield, sugar cane was planted during the rainy season between the months of June and December. On the other hand, reaping of the sugar cane took place 14-18 months later, during the driest months of the year, January to June. It was also the period when the sugar content was at its highest.

The weekly allowance for a field slave consisted of three to five quarts of horse beans, rice or Indian corn, together with three or four salt herrings or two pounds of salted beef or pork. Alternatively, the proprietors of the estates issued yams, eddoes, guinea corn, sweet potatoes, plantains and bananas in the same proportion when the estate produced such provisions. Other personnel in the community of the proprietors included House/Domestic personnel (Lawrence, 2008).

House Domestic Personnel

Plantation proprietors housed domestic unpaid servants in huts on the premises of their mansions. They fed them from the kitchen; although, some opted to accept three bits, just over a shilling, per week to feed themselves. Those involved in the proprietor's personal welfare, or who worked closely in association with him, occupied rooms in the Great House. These included waiting men, whose work included task recommended by the proprietors about his personal welfare, waiting maids, dealing with personal welfare of the mistress of the plantation, seamstresses, making garments and other work associated with this profession, butlers, in charge of all other domestic male servants and the welfare of the proprietor and cooks with responsibility for meals and nurses caring for the sick.

However, there was a noticeable difference, in the lifestyles of the slaves working on the plantations and those living in the city. The 'owners' of the city slaves hired them out as craftsmen and trades men. With their skills these city slaves could work outside the boundary of the estates/plantation thus earning money. Additionally, they were able to engage in other activities outside of their mandated terms of employment. In the next section I examine the role of doctors on the plantation.

Doctors and Specialists

As recorded by Lawrence and Gordon (2013, p. 14):

> *Antiguan law No. 36 A.D. 1798, under penalty of £100, required estates to have a hospital called a sick house. Most of them were unsuited to promote good health. Lack of equipment and lack of a sanitary environment were noted as the chief reasons. Young doctors contracted by the estate owner or their attorneys cared for the sick twice weekly. While most doctors of this era were Scottish, some enslaved Africans and Creoles, despite not possessing formal medical training, served also as physicians to any one on the plantation. They had a measure of confidence, self-worth and intellect, which were recognised by their enslavers.*

The Great House's community could never be complete without its compliment of estate animals. The main ones were oxen, horses, donkeys and mules. They too had independent assignments to perform. In the next section I examine the task that informed their work on the plantation.

2.5 Sugar Industry Managerial System

To accommodate management of the estate's work, different positions were assigned to workers (Division of Labour). These positions existed until the Antiguan and Barbudan sugar production ceased in 1971. Positions included: attorney, manager, senior overseer, junior overseer, ranger, driver, groom, stableman and messenger. This was the nature of their work:

- The ***attorney*** was responsible for a group of plantations. Since many of the planters lived in England, they appointed attorneys to oversee their estates. One attorney lived on every block of the estates in a luxuriously furnished Great House with many servants. They were not usually involved with the day to day running of the plantation, thus hardly coming into contact with the workers. However, occasionally, along with the manager and the senior overseer the attorneys would ride around the estates to see how things were operating.

- The **manager** lived on the estate of which he was in charge. He took orders from the attorney. In turn, the manager gave orders to the senior overseer. The manager's role was chiefly one of ensuring that the work for the absentee landlord was being accomplished.
- The **senior overseer** was responsible for preparing the pay list for work done by each plantation worker. This was a list that he had to present to the manager every Monday morning. Both pay list's and pay sheet's figures had to be identical when noting employees' remuneration. Irrespective of the nature of employees' work each had to be documented, priced and paid. The work ranged from cutting cane by line (row), loading cane by line, trimming of plants, and dropping fertilizer. The difficulty for the overseer came when a worker was engaged in more than one of these jobs. Accuracy was questionable. Nonetheless, in many instances, the pay list was tallied accurately, despite the lack of techno mathematical devices or computers. Later plantation owners assigned junior overseers to aide with the work.
- The **ranger** also resided on the plantation. Although his position was that of a lower rank and a lower social status than the overseers, the labourers feared him more than the latter. This was a result of the Ranger working closely with the labourers, where he ensured that the work was appropriately done. When the overseers had to leave he would be in charge. In addition the Ranger was manager of the plantation's stores. This meant that he distributed and recorded accurately, all issuances on the plantation: diesel; fertilizers; hoes; cutlasses and raincoats. There was a labour force of over 300 workers on a plantation.
- The **driver** was in charge of Gangs and would flog workers whom he deemed were idling on the job. The Driver also measured the number of lines of cane labourers cut. This was the first step in tallying of workers' pay. In terms of gender, drivers could be either male or female.

- The **grooms** on the plantation brushed and prepared the manager's horses. Horses were their main means of transportation.
- A **workers' foreman** acted as leader, spoke person, and disciplinarian for his gang. His responsibility also included negotiating better deals for his workers.
- The **stableman** as the name implies kept the stables clean.
- The **messenger** ran errands of all kind for the plantation management.
- The **trench men packed** the trenches to facilitate trailers crossing them. Deep trenches existed on the plantation over which trailers passed.
- The **yardman** supervised the men who cut grass at the sides of the roads to feed the horses.

Today in the sugar cane fields, the tractors, and the workers have all disappeared. So too, the hustle and the bustle of plantation life have ceased (Lawerence, 2008). However, it must be noted, that beyond the boundary of plantation life, other economic activities were part of the economy of Antigua and Barbuda. In the subsequent section, I examine some of these economic activities, with the view of assessing the nature of the mathematics informing these economic activities in the analysis of Chapter eight.

2.6 The Blackman's Struggle

Emancipation did not make illegal economic exploitation and social deprivation imposed on the Negroes. Nor did it provide acceptable education for them. Meaningful economic, social and political progress did not coalesce for most black Antiguans and Barbudans until more than 100 years after emancipation with the formation of the trade union movement. Even then they had to fight off mounting pressure from the ruling class. Many school age children had to sacrifice their education given their lack of adequate clothing, or the need to toil in the fields alongside their parents to make ends meet. Additionally, children were forced to sacrifice their education and work on the plantation to meet a residential stipulation of having one member of the family working for the estate in order to be considered as a member of the estate. Hence as in the case of my father to keep a roof over the family's head he was forced to leave school at age nine years old. Groom's boy, stable man, and a member of the small dung gang were his areas of work.

Despite the obstacles, a few black men succeeded in business during the early years. For example:

- Brothers Benjamin and Billy Johnson (1700s) to whom Dutch slave owner, Margaret Low, bequeathed freedom from slavery and all her possessions. She had educated them so well that they qualified to operate a business. By 1736, they were worth thousands of pounds. However, they were charged along with King Court and others for inciting a takeover of the country. They managed to escape the death penalty.

From the late 1800s into the 1900s black Antiguan and Barbudan businessmen, J.A.N Brown and Jim Pigott became very wealthy buying and selling general merchandise in St. John's. Business still flourishes in the Piggott's Building. Another black businessman, John Isaac Martin was born in humble circumstances in Point, St. John's, on 6th March 1892. He left school at the age of thirteen becoming a butcher. His peculiar way of cutting meat, earned him the nickname of 'choice cuts'. At age eighteen he left Antigua and Barbuda for New York, where he continued his profession. He later married one of his customers, a woman of immense means.

As an avowed anti-colonialist, he now had means to make a difference in his native land, which was shaped for centuries by white plantocrats. They relocated to Antigua and Barbuda, set about buying up choice real estate and every available estate. Additionally, he went on buying domestic animals, a fleet of buses, and heavy duty equipment; thus providing employment for a good number of people. Following his demise in 1971, one of his sons has taken over the business, which today operates under the name, Willy D. Enterprises (Hector, 1984).

Today, many black businessmen own or share ownership of many island enterprises. Additionally, some control multi-million dollar operations. However, the biggest single employer in Antigua and Barbuda is the government. With the closing of the sugar industry, tourism became the main industry. However, this one industry put the economy in the same situation as the sugar industry. There was the need for other industries if the state was to give our growing cadre of young professionals the type of industries that would meet their expectations. The aim was to develop a sector of the economy to absorb the skills of these new professionals.

To accomplish this new economic thrust, the government turned to a strategy of *service industry.* Thus, using the rapid growth in telecommunication industry, investment was pursued in such areas as offshore banking, gaming industry, insurance, banks and backroom industry. All this was done taking advantage of the fact that the mother tongue of the citizens was the language of international commerce, geographical positions vis-a-vis United States of America and Europe, highly developed communication services and international air services.

The key to the success of this new direction of economic activity was the provision of incentives to first world entrepreneurs and their companies to relocate and allocate significant resources to Antigua and Barbuda. For example, offshore banking in tax free and duty free environment, financing goods and services brought into Antigua and Barbuda tax free and duty free. The sole intention of the government was to attract areas of employment for the aforementioned young professionals returning to make their contribution to national development and growth. The gaming industry which was aimed at rich North American gamblers did in time employ thousands of school leavers.

Also contributing to employment in the economy was *Backroom Industry*. This included specialized operations of national companies based in North America and Europe were attracted to Antigua and Barbuda, so that local workers could perform tasks to include preparation of payroll for various airline, construction/manufacturing of transformers, film industry, where making of infrastructure and shipping to original country of the industry, and assembly of television sets for large co-operations. To accommodate these industries, an area known as the Free Trade Zone was established. In this area industries including binocular and spectacles manufacturing, other high tech-industries, and other products that were outsourced formed the backbone of economic activities. In this environment outsourcing entrepreneurs could use comparative cheap labour, well trained population, and easy access to metropolitan countries using telecoms, shipping, and aviation services to produce cheaper products than could have been manufactured in their homelands. These industries were used to complement the tourist industry.

With no critical mass to compete in manufacturing, niche markets were the best economic activities to pursue. Hence, attracting high techno-industries with the aim of manufacturing specific components, this could then be exported to their first world corporations provided employment for school leavers in Antigua and Barbuda during the 1980s. Low taxes, educated populace, where the language of commerce – English - was the mother tongue could be attributed as responsible for the success in economic activities informing the labour force (Cordelle). In the next section I examine the development of education in the societies of Antigua and Barbuda.

2.7 Nature of Mathematics Education

The nature of activities informing work in the colonial era up to present times warrants the questions: what was the role of mathematics education? What was its contribution to national development? In the next section I examine the first taste of formal education.

2.7.1 First Taste of Formal Education

'Up to 1736, the ruling class had kept slaves away from the church, referring to them as heathens. That changed on 1st April 1756 when a Moravian Missionary, Samuel Isles, introduced the gospel to the slaves' (Samuel, 2007, p. 1). The Methodists followed in the 1770s. At first, the planters thought they would lose control over their slaves. However, soon they realized that religion could make the slaves more tractable and patient. This would result from their hope for a better life after death.

Another fear weighing heavily on the minds of planters was one of an educated slave population. The mind-set of the planters focusing on this fear can be seen in this sentence: 'if they are not instructed in any arts or skills other than those required for their unpaid labour, they are less likely to contemplate alternatives and so resist their masters '(Gordon, 1963, app). In her Book: *Bethesda and Christian Hill – our history & culture,* Lawrence (2008, p. 9) records that:

> *Basic education began for some Negro children shortly after emancipation (1834) beginning with mission schools teaching them to be obedient and righteous. In overcrowded classrooms, the students received instruction in basic reading and writing with a little arithmetic. Abolitionists Sturge and Harvey (1837) visited Willoughby Bay after emancipation. They remarked that 20 out of 120 pupils were learning the alphabet, while the rest could read one or two syllable words. A few could read any part of the bible. Although quite an accomplishment at that time, it would prove unsatisfactory. They observed that pupils learned by rote. Not a tool for developing the mind.*
>
> *Parochial school lessons consisted of reading, writing, and arithmetic, repetition of catechism, hymns and plain work for the girls'. Much emphasis was placed on religion and showing respect for visitors and those in authority. At Willoughby Bay, children showed respect for visitors by standing when they arrived. They also showed proficiency in reading scriptures (Lanaghan, 1991, Volume 1, p. 318).*

Historical notes on Education in Antigua and Barbuda indicate that the Methodist superintendent, Thwaites (1837) was in charge of 17 schools, 21 teachers, 1250 scholars, 21 teachers, with a teacher: pupil ratio of 1:59. This led to the introduction of a system where a qualified teacher would instruct a number of students in a subject, which they in turn taught to other students (Antiguan poet).

The Spring Gardens Moravian Teachers Training College, founded in 1854, improved the supply of qualified teachers. 'Ninety-four-year old Alfred James reports that the pupils–as-teacher system lasted well into the 20th century' (Antiguan poet). Education improved for some in 1884 when the Reverend S.E Branch established the Antigua Grammar school for boys. An advertisement in the Antigua churchman of 1887 listed these classes as: Divinity, Latin, Greek, mathematics, English and French. Extra offerings included vocal music, instrumental music, drawing, and book keeping.

In 1886 Mr and Mrs Williams offered secondary education for girls, when they founded the Antigua Girls' High School. The Antigua Girls' High School apparently offered some but not all of the subjects taught at the Grammar school. A past student in 1986 mentioned subjects taught as drawing, mathematics, Latin, French, history, English and botany, the latter taught by a Grammar School Teacher. Extra-Curricular activities included tennis, croquet, and cricket. Another ex-pupil listed subjects taught in 1940 as dictation, French, needlework, handicraft, scripture, English including poetry, art and that they had to go to Antigua Grammar school for botany and chemistry. However, both schools charged a fee and admitted only legitimate children. These stipulations excluded poor Negro children.

In 1898 Nellie Robinson, a young black woman at age 18 founded the Thomas Oliver Robinson Memorial High School. The consequences of this were an easing of some of these restrictions on schooling and the ultimate paving of the way for free education in the 1900s.

Notes from Theme and Kimball (1838) in the book *Emancipation in the West Indies: a six months' tour in Antigua, Barbados and Jamaican the year 1837* claim:

> *They found Rev. Morris, the missionary, at that (Newfield) station, in charge of two thousand people. He had a day school for children and a night school for adults twice a week. The day school began with children kneeling down and repeating the Lord's Prayer. The first exercise was an examination of a passage of Scripture. The children were then questioned on the simple rules of addition and subtraction, and their answers were prompt and accurate.*
>
> *However at the adult school for women, about 30 women assembled from different plantations – some walking several miles. Most of them were just beginning to read. They had just begun to learn something about figures, and it was no small effort to add 4 and 2 together. They were incredibly ignorant about the simplest matters. They didn't know their cheeks from their chins; nor left from right. They could not tell the time, Mr. Morris reported to the visitors, Thome and Kimbal (1838). Such is a specimen of the intelligence of the Antiguan Negroes. However, they also remarked that they had a great desire to learn (Thome & Kimball, 1838, p. 15).*

A different perspective of the black population is given by Mr Charles Thwaites, superintendent of schools, who had under his charge 11 day schools, with about 800 scholars and 3 Sunday Schools with about 900 scholars. Lanaghan (1844) presumed author of *Antigua and the Antiguans* wrote:

> *The blacks certainly had not the means of improving themselves in former years as the more fortunate had since emancipation. However to state that the whole class were so totally ignorant as not to be able to read, is entirely incorrect (Langhan, 1991, p. 320).*

In proof of that Mr Thwaites referred to several teachers who were adapted for their employment, in particular, one teacher who conducted a school consisting of 120 scholars, whom he instructed in 'reading, writing, and arithmetic (Lanaghan, 1991, p. 320).

My mother was born in 1918. The formal education available was only at the primary level. Completion of this tenure of education was rewarded with a Seventh Standard Certificate. The certificate was achieved subsequent to taking and passing the examinations in English, mathematics and general paper. Table 2.1 below provides the information for the content of these tests.

Table 2.1: Content of disciplines for the acquisition of the Seventh Standard Certificate (early 1900 to approximately late 1950) (Michael)

Subject	Content
English Language	Parts of speech, identification of direct and indirect speeches, transposition from direct to indirect speeches and vice versa; identification of predicate and subject in sentences; parsing (included identification of the role of each word in a sentence); paraphrasing; dictation and comprehension (Michael).
Mathematics	Problems focussing on arithmetic topics of money, measurement and numbers. Hence content included problems focusing on addition, subtraction, multiplication and division of money problems where the currency was sterling: £ (pounds), s (shillings) and d (pence); conversion of currency from sterling to dollars and cents and vice versa; measurement using imperial units to include: pounds (lbs), ounces (ozs), bushel, stones; measurement using inches, feet, and yards. Later, there were logarithmic problems (Michael).
General Paper	Topics in history and in geography (Michael

This certificate was one for matriculation of the holder to enter directly into the world of work. Nature of work and the workplaces were limited to:

- The sugar plantations
- The great houses on the plantations
- The Sugar Factory and its subsidiary stations and office
- The American Navy Bases (laundry department)
- Education department: as teachers
- Farmers: vegetables and animal husbandry
- Fishermen and boat builders

The introduction of secondary education in the 1940s brought a change to the syllabi informing disciplines taught in schools in Antigua and Barbuda. The London and the Cambridge overseas Examination Boards were responsible for syllabi and subject content of subjects taught in schools. Regarding mathematics there were two types of syllabi:

(i) Syllabus A comprised three branches of mathematics:

- Arithmetic
- Geometry and
- Algebra

There were individual examination papers for each of the branches.

(ii) Syllabus B comprised an integration of the three branches of mathematics to include:

- Arithmetic
- Geometry and
- Algebra

School leaving certificate examinations were tested using two papers with each of the branches included in the composition of the test items.

The certificates from these examinations had as their main focus studies for higher education. Hence, the focus was catering for students choosing trajectory for tertiary education and matriculation for entrance requirement for University subsequent to completion of 'A' levels studies in the discipline.

By 1960 when I entered Parham Government school as a student, my recollection of my mathematics lessons in my Infant 1 classroom was that of using the covers from aerated soft drinks to help with addition of numbers based on place value using the subheads of units and tens. This was expanded upon in infant 2, where the place value representing hundreds was added to the content (1960-61). In Junior 1 and Junior 2 it was still the arithmetic branch of mathematics forming the content of lessons. Topics included fractions, rules for the multiplication, division, addition and subtraction of fractions, finding of lowest common multiple (LCM), and Bills. The same teacher was in charge of both classes. Hence topics were started in Junior 1 and expanded upon in Junior 2. (1962-63).

At Junior 3 and Junior 4, where one teacher was again in charge of both classes, worded problems were added to the content. Hence problems of the 'since, then, and therefore' category comprised the mathematics lessons. Fractions and other numerical problems were also administered (1964-65). At the beginning of the junior 5 year, it was a mixture of worded questions of the since, then and therefore category, simple shopping bills, fractions, ratio and proportion which formed the backbone of mathematics lessons.

At the beginning of the second term of the Junior 5, I left Parham Government School, having won a scholarship to my new school, Sunnyside International. However, not wishing my former classmates to increase their mathematical knowledge ahead of mine, I would ask my cousin who was a member of my former junior 5 classes at Parham School, to show me her mathematics class book, so that I could view what was being taught. It was on one such occasion that I found out that the branch of arithmetic comprising selling price, cost price, discount, profit and loss, percentage, percentage of cost price, percentage of selling price, discount per cent were part of the content of the mathematics taught in junior 5. This was also the year when the class would have been preparing to handle the mathematics examination for the 11+ year old students in preparation for the transition to secondary school.

Hence I would conclude that for Primary mathematics education during the 1960-1970 era in Antigua and Barbuda, topics taught included:

1. Natural Numbers
2. Place values
3. Sequencing and grouping of numbers (learning of tables)
4. Fractions
5. Information of meanings for the words: a score; a gross; a dozen; a century; a decade and a baker's dozen
6. Word problems of the 'since then and therefore' format
7. Word problem of the 'if, then' format, ratio and proportion (for example, how long would it take 14 men to build a wall if it takes 6 men 4 days?)
8. Areas, perimeters, of 2-D shapes: specifically rectangles and triangles
9. Volume of solid, specifically cube and cuboids (Lx W x H)
10. Bills mainly shopping for goods
11. Problems focusing on: selling price; cost price; percentages; selling price as a percentage of cost price; discount; profit and loss.

Thus mathematics education in the primary school came from the arithmetic branch. Additionally, the focus of the primary school's mathematics education was to prepare students to pass the 11+ examinations (1960-2012).

When I entered secondary school, the mathematics program was governed by the content outlined in the Cambridge University Examination Board's syllabus for overseas territories. Two new branches of the mathematics discipline were now part of my lessons: algebra and geometry. I discovered that the main focus of secondary education was to prepare students (my perception) for tertiary education. Hence the full content of secondary mathematics during the period 1967-1974 was founded upon the content as outlined in the Cambridge syllabus. The content of the Cambridge Examination Board syllabus for mathematics governed mathematics education in Antigua and Barbuda until 1979, when there was a change in examination board. The change in examining board was made after ratification by the heads of government in the Caribbean, supporting the motion to make the Caribbean Examination Council the examining body governing secondary school leaving certificates for their citizens.

Although the decision was taken in 1968 to make the Caribbean Examination Council's Board the examining body for Caribbean students, Antigua and Barbuda did not make the change until 11 years later. This was to accommodate the independent research of the government on the legitimate acceptance of the certificates universally by institutes of higher learning. Once this assurance was ascertained and endorsed by universities globally, the switch was made.

This change in educational policy was made simultaneously as the change in economic activities in the country, from a monoculture sugar base economy, to an economy where tourism was the backbone of economic activities. To avoid a replica of a monoculture economy, with nationals, now newly academicians returning home with qualifications in various professional trajectories, there was the need to create a sector in the economy to accommodate independent entrepreneurship and introduction of new sectors professionally in the economy. The decision for diversification of the economy resulted in the introduction of the service based industry.

The service industry added economic activities and job opportunities in manufacturing, cottage industry, construction, banking, insurance, finance, gaming, offshore banking, free tax zone areas, thus luring investors from the first world to our shores (out sourcing operations in business facilitated the move). Since they could utilize a cheaper labour force, well-educated labourers, and easy access to land, sea, and internet communications to North America, to other trading countries and globally, while working in an environment where the language of commerce and industry – English - is the mother tongue of the employees. All this guaranteed an increase in the profit margin of their businesses. Profitability in business would be heavily dependent upon the ability of the Antiguan and Barbudan Government to provide investors with an educated labour force. The secondary schools in Antigua and Barbuda were designated as the institutions responsible for fulfilling this mandate.

During the colonial era the labour force was tied to the land; sugar cane was the backbone of economic activities. However, these economic activities were of no benefit to the local economy. Profits from the industry were exported to England, without any attention being paid to develop the local economy or country. Neither were the educational policies associated with the appropriate preparation of citizens for the labour force. Indeed there was no need for such a policy, since for the most cases the requirement of workplaces of its employees was for muscles and for strength. Mathematics was not a requirement for the school leavers seeking employment in the workforce. The mathematics required for work was little arithmetic, performed as operations (counting and measuring lines of canes; digging holes for planting young canes 3-4 feet deep).

On the contrary, today with an increase in techno-mathematical literacies (Hoyte et al., 2010) informing workplace operations, the requirement of labourers for the workplace has changed. This requirement is for employees to be highly trained in technological skills and to be in possession of techno-mathematical literacies skills. This training should be part of the curriculum in secondary schools. Teachers, therefore, should be prepared to act as facilitators to ensure that students are appropriately prepared to handle the mathematics in the workplace and additionally, that school leavers were in possession of techno-mathematical knowledge and skills to handle daily routines in the job market.

Since I know that a few decades ago workers were without technological knowledge, guaranteed training on the job at all workplaces, with the latter no longer available to school leavers entering directly into the job market (World Bank researchers, 2007) and with mathematics a mandatory requirement for those seeking employment in the labour market, my research is seeking suggestions.

2.8 Summary

In this chapter, I offer a historical account of changes in the Antiguan and Barbudan economy. I examine the activities informing workplaces in this era. I also evaluate the mathematical knowledge that is used by labourers in their daily activities. I argue that whereas technological skills were never addressed as part of the knowledge base of worker's preparation for the monoculture economic system during the colonial era in Antigua and Barbuda, today it is quintessential for labourers to be technologically literate when seeking employment in the 21st century's labour market.

In Chapter three, I will examine the literature informing workplace mathematics in Antigua and Barbuda, with the view to ascertain how effective was the preparation in allowing the new employees, who enter directly into the workplace after their graduation, to handle the mathematics at their various worksites.

Chapter 3 - Literature Review

3.1 Overview

In this chapter, I draw on the work focusing on mathematics in the workplace. I am concerned with the link between the society, the workers and the mathematical problems facing them in the workplace.

3.2 Introduction

Over the past three decades, there has been a growing interest in the field of workplace mathematics which has provided a rich literature base exploring the various dimensions and perspectives globally (Australia, Canada, Denmark, Germany, Netherlands, Scotland, New Zealand, India, China, Singapore, United Kingdom, Brazil, Sweden and the United States).

In the literature one theme is 'the invisibility of mathematics in technology and the transfer of mathematics from school to work and vice versa are two of the key issues in the problem field combining workplace technology with mathematics education' (Wedege, 2011, pp. 1-2). These two areas are also the main foci of my research.

With no empirical study of the specific mathematics practiced at the different worksites in Antigua and Barbuda, my role is one of being able to identify the mathematics at sites. It is also pertinent to my being able to assess whether or not students are appropriately prepared for their roles. There is a third dimension to this problem:

> *There is a problem concerning the lack of recognition of the workers' everyday competences. Workers develop their mathematical competences through participation in the workplace community of practice'. (see, for example, FitzSimons and Wedege, 2007; Hoyles, Noss and Pozzi, 2001; Nunes, Schliemann and Carraher, 1993). Nevertheless, it appears that [employers'] beliefs about mathematics are primarily related to their school experiences, and that mathematics is experienced by many adults as something that others can do but that they themselves cannot do (Wedege, 2011, pp. 1–2).*

This inability of employers to precisely identify the true capability of the new employees to handle the mathematics in work only serves to falsify and provide erroneous information on the competency of the workers to handle appropriately mathematical problems at their worksites. It also serves to demean the capacity of the newly employed to cope with workplace mathematical problems. Simultaneously, it serves to highlight the lack of knowledge on the part of employers to recognise the nature of the mathematics at their worksites, how it is learned by the workers and the difference in the function of mathematics in the job market – functioning as a *tool* when compared to its classroom function -where it is the *object* of the classroom activities. Hence there is a need to assess claims made by Antiguan and Barbudan employers, of school leavers being unable to handle the mathematics in work, since such claims could be based on perception rather than empirical facts.

3.3 Nature of Workplace Mathematics

What is involved in this exercise of describing mathematics in the workplace? This is the first question that a researcher should ensure that s/he can answer. In this research, 'characterising mathematics in the workplace involves attending to the actions and reasoning that might count mathematical in this context' (Nicols, 2002, p. 293). Mathematical reasoning in the workplace can be quite different from mathematical reasoning found in a school classroom (Williams and Wake, 2009; Wake, 2011).

This growing body of research whilst indicating that 'school mathematics cannot be transferred to the workplace and that learning takes place in context, seemingly argue that to be successful in out-of-school contexts people need to develop situation specific forms of competence. Smith (1999) emphasizes how purposes, structures and products frame the mathematical practices of work and school' (Nicols, 2002, p.293). In the workplace, for example, the standard numerical algorithms taught in school are often not the ones used by workers on the job (Hoyles and Noss, 2001). In this 'context the use of mathematics tends to emerge from the activities and tasks of work' (Nicols, 2002, p. 291). 'For example, mathematical calculations can develop in the workplace as a result of proportional or relational reasoning about quantities' (Noss, 2001, p. 294).

In school, on the other hand, students are most often involved in mathematical activity for the purposes of learning mathematics within a school subject. What counts as mathematical thinking and what counts as mathematical in a school context is more easily defined by the structures of the school day. For example, contrary to mathematical reasoning in the workplace, learning mathematics in school is scheduled for particular times within the school day. During these times mathematical calculations are often required of students in solving problems that reasoning Behr, Harel, Post, Lesh, 1992), making topics such as proportional reasoning a difficult mathematical concept for students (Nicols, 2002, p. 294).

These characteristics of mathematical operations in school are also prevalent in the schools of Antigua and Barbuda.

A claim by Wedege (2001, p. 41) is 'that a significant difference between adult numeracy and mathematics is that the idea of society and the need for mathematics in adult life are incorporated in numeracy but not necessarily in mathematics'. In defining the term numeracy Johnston and Yasakawa (2001, p. 41) deem it 'as a critical awareness that builds bridges between mathematics and the real world'. [For them], in teaching numeracy it is 'the relationship, the negotiation, between mathematics and the world that has become the core concern' (Wedege, 2001, p. 41). Groenestijn (2002, p. 37) states:

Numeracy encompasses the knowledge and skills required to effectively manage mathematical demands in personal, societal and work situations, in combination with the ability to accommodate and adjust flexibly to new demands in a continuously rapidly changing society that is highly dominated by quantitative information and technology.

In a world where technology is an increasingly important factor there are in society, three complex relationships between technology, mathematics and people (Wedge, 2001). She argues that the concept of 'technology' in the labour market comprises three mathematics-containing elements: (i) technique/machinery, (ii) human qualification/competences and (iii) work organization. Their dynamic interrelation is crucial in studies of adults' mathematics in the workplace.

3.4 Mathematics in the Workplace

There can be no doubt about whether people learn mathematics out of school. It has been established that children's understanding of number begins before they have been to school *(Piaget, 1952;* Gelman and Gallistel*, 1978;* Hughes, 1986). Secondly, unschooled adolescents and adults routinely perform calculations at work, in naturally occurring situations (Scuber, 1984; Carraher and Schliemann, 1983, 1985; Schliemann and Carraher, 1988 and 1990; Lave, Mustaugh and de la Rocha, 1984).

In addition, people who have been to school occasionally represent, solve or think about mathematical problems in daily life so differently from how they are taught in school that it is difficult to deny that something important has been learned or discovered outside of school. In fact, her further claim is that it can be reasonably argued that schooled people develop a substantial part of their mathematical knowledge out of school'. However, despite these facts, the main question is not whether people can or do learn mathematics out of school, but rather what is the nature of mathematical knowledge learned out of school and how is it similar to and different from mathematics learned in school? Carraher (2000, p. 123) asks:

> *What are the principal characteristics of this knowledge? How is it organized? How is it acquired? To what extent is it taught by others? To what extent is it discovered or constructed by individual? How is it deployed in actual settings or situations? What sort of problems is it particularly suited for? How extensive, flexible, unified, general, explicit, precise, abstract, and powerful is it? How is it related to cognitive development in general? How is it looked upon by the people who use it? What sense do they make of it? What symbolic representations, internal or external are associated with the knowledge and what role do these representations play in understanding or solving mathematical problems? What modifications are introduced in representations and procedures as people confront new situation?*

These are the questions that underpinned my data collection exercise.

3.5 Mathematics and Black Boxes

Like Nicols (2002), Williams and Wake (2007):

Noted how workers, students and even teachers found difficulty in identifying mathematics in workplaces. They reported of some research having 'concluded that workplaces demand minimal mathematics (Riall & Burghes, 2000) while others say rather that significant mathematical demands arise during particular 'breakdown' moments when routines are challenged by new or unusual situations (Pozzi et al., 1998), or that mathematics may be difficult to recognise because it is bound up or hidden in black boxes by technology' (Hall et al., 2002 cited in Williams and Wake, 2007, p. 320). Williams and Wake (2007, p. 320) have claimed that 'some in mathematics education have used the term black box for the result of this technological process, and have sought to clarify how technology can also serve as a means to illuminate what is hidden in these black boxes. This approach has been applied by Noss, Hoyles et al. (1996, 2002) to workplace mathematics, where they also refer to activity theory and to Leontev's notion of crystallisation'.

Furthermore, declared Williams and Wake (2007), 'Straesser (2000) suggested that hiding mathematics in black boxes signals an increasingly mathematical social life, even while workers and professionals continue to report that mathematics is progressively becoming invisible, 'disappearing' from the workplace' (p. 320) Straesser (2000) gained support from Williams and Wake (2007, p. 320) in making the assertion that 'this contradiction is at the heart of the problem for vocational mathematics education'. It is the belief of Williams and Wake (2007, p. 320) that the value of their research will come from the ability of 'their theoretical work building on and adding to these concepts of break down and black box: in particular their ability to show two processes by which black boxes are formed and how these processes shape as well as hide the mathematics involved in distinct ways'.

Thus taking Latour's (1987) very broad view that historical and cultural processes hide mathematical and scientific work, inter alia, in 'black boxes' which not only include machines, but also ideas, concepts and scientific facts. Williams and Wake (2007) claim that 'the term black box is drawn from cybernetics and is used 'whenever a piece of machinery or a set of commands is too complex for ordinary members not working on the operation line to understand the rationale or logic for the commands. In its place they draw a little black box about which they need to know nothing but its 'input and output' (Latour, 1987, pp. 2-3 cited in Williams and Wake, 2007, p. 321).

For Latour (1987, pp. 2-3), a network becomes a black box for the user, because 'it acts as one piece when many elements are made to act as one that is what I will now call a black box' (p. 131 cited in Williams and Wake, 2007, p. 321). Later Latour (1999, p. 304) defined *black-boxing* as referring to:

> *The way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one needs to focus only on its inputs and outputs and not on its internal complexity. Thus paradoxically, the more science and technology succeed the more opaque and obscure they become.*

3.6 Workplace Mathematics: Different Settings

In this section I analyse workplace mathematics from different perspectives in different national contexts.

Forman and Steen (2000, p. 83) state that 'there are more mathematics in the workplace than people expected or readily recognized, even in jobs performed by students who have had to struggle to learn mathematics'. 'The narrow experience of school mathematics had so limited the mathematical understanding of many adults that even experienced workers often failed to recognize the mathematics they actually employed' (Forman and Steen, 2000 cited in Bessot and Ridgeway, 2000, p. 83).

One example of this is the *Slow Learners Organisation* (SLO) *projects* in the United States. The project '[suggested] that workplace mathematics fell naturally into four categories: (i) three dimensional thinking, (ii) use of complicated information systems, (iii) measuring and calculating diverse amounts and (iv) following rules and procedures. The researchers also found that only elementary and non-formalized mathematics was involved in each of these categories, but the situation in which the mathematics was used was usually fairly complex. To test their hypotheses about teaching mathematics for the workplace, the Slow Learners' Organisation (SLO) researchers translated several work place scenarios into 'story-lines' for teachers to use in the classroom.

These proved quite effective when motivated by well-prepared teachers, but less so when students were expected to learn from the teaching materials alone. The researchers further reported that student work on projects based on these work-based story lines was serious and professional, in contrast to slow learners' typical attitude towards traditional school mathematics' (Steen and Forman, 2000 cited in Bessot and Ridgeway, 2000, p. 84).

Hogan and Morony (2000, p. 87) described a somewhat similar effort in Australia, but with important differences.

> *One of the several 'key competencies' defined in a 1992 Australian report on employment and training is 'using mathematical ideas and techniques' because people often ignored or misinterpreted this competency – probably due to widespread adult avoidance of mathematics- the Australian Association of Mathematics Teachers (AAMT) launched a project called 'Rich Interpretation of Using Mathematical Ideas and technique.*

The goal of this project was to generate descriptions of how mathematics manifests itself in workplace situations. The RIUMIT project was carried out by Mathematics Teachers who engaged in highly structured job-shadowing followed by interviews that led to written descriptions of workplace tasks that highlighted the embedded roles of mathematics. The goal of these teachers was to describe what happens in work situations without imposing any predetermined view of mathematics.

In the Netherlands, Australia and the United States, as in most nations, most people assume that mathematical preparation is essential for jobs. Thus projects such as SLO, RIUMIT and the various United States standard efforts do not ask whether mathematics is indeed necessary, but rather seek to clarify the kinds of mathematics required and to implement these kinds of mathematics in curricula. This is one of the missions my research seeks to achieve for mathematics education when developing the curricula in Antigua and Barbuda in the future.

3.7 Transferability of Mathematical Knowledge

Evans (2000, p. 5) claimed that contrary to popular belief transfer of mathematical knowledge from one context to another is not achieved easily. This might involve:

- Acclamations that contrary to popular belief transfer of mathematical knowledge from one context to another is not reformulation of academic discourses as school subjects;
- The use of mathematics outside its own domain, example in physics or economics;
- The application of knowledge from pedagogic contexts to work or everyday activities; or
- The 'harnessing' of out-of-school activities in the teaching of school subjects (Evans, 2000, p. 5).

Although I support scholarship in foregrounding the aforementioned as 'important set of issues for mathematics [since] the claim is to have very wide applicability across the curriculum and outside the school' (Evans, 2000, p. 5), only (3rd bullet point) and specifically applications in work contexts will occupy my focus in this argument.

My argument begins at the juncture where Evans (2000, p.5) begins his debate by stating that:

> *In practice, transfer remains a difficult problem: one cannot depend on its being accomplished, by a particular learner, in a particular situation. He justifies this assertion by stating that 'there is much anecdotal evidence that teaching often has disappointing results in this respect: in fact students often 'fail' to accomplish transfer.*

In fact research has shown 'striking differences between levels of performance - and methods used - in work, or everyday situations, on the one hand and in school, or school-type tasks on the other' (Nuns, Schliemann and Carraher, 1993, p. 6).

3.7.1 Transferability

An article from research carried out by Evans (1999) on the transfer debate has been adopted for my research by kind permission.

Research on transfer has claimed that:

Mathematics educators have always maintained that the mathematical knowledge that students acquire in school should be able to be adapted and applied in the workplace and everyday situations. It has also been recognised by the community that, far too often, it does not happen. Theoretical explanations for this failure depend on the author's views on the nature of the boundaries between the practices involved (Evans, 1999).

Three main positions can be identified in the literature:

(1) The boundary between the everyday and school mathematics is permeable and theoretically unproblematic, though practically a considerable challenge for pedagogy. Inadequate instruction or inadequate learning can result in [insufficient] understanding (Skemp, 1976). Here, some authors emphasise the value to students' learning of the use of authentic contexts (Sullivan, Warren & White, 1999).

(2) Transfer is not possible, because of the impermeable boundaries between contexts and practices. These include the [prevailing] view (often drawing on Lave (1988)) that meanings are produced and remain within specific social and cultural practices.

(3) Transfer is problematical, since boundaries exist, and are not automatically crossed, but still it is possible to enable something like 'transfer'. This includes the use of concepts such as 'consequential transitions' (Beach, 1999), 'translation' (Evans, 1999, 2000), and 'recontextualisation' (Cooper & Dunne, 1999). Amongst those who consider the boundary as problematic, Boaler (1998) argues that developing identities in communities of practice in which "students are acculturated and apprenticed into a system of knowing, thinking and doing" (Boaler, 1998, p. 118) might be helpful in enabling students to transfer their knowledge (see also Goodchild, 1999).

In his recent work, which involved revisiting the contentious topic of transferability of class room mathematics to the workplace, it is the claim of Wake (2011) that:

Recent involvement in research into proposed curriculum change in mathematics in England, and into proposed curriculum changes in mathematics in England, and into transitions into mathematically demanding courses in University, has provided additional insight into the central issue of transfer: that is, the use or application of mathematics in a range of different settings (International Conference of Mathematics Education, ICME-12).

Additional arguments from Wake (2011, p. 8) declare that:

In the last two decades or so many researchers have contemplated and examined the overarching question of how transfer might be conceptualised and better supported. His view was that extreme positions in the debate might be characterised as those of, on the one hand, proponents of situated cognition (that is, that knowledge is developed in social settings by individuals in interaction with others and is dependent upon the cultures, traditions and values of the community), (see, example, Lave (1988) and Lave and Wenger (1991));

whilst on the other hand, proponents of the classical psychology and information processing perspective (with knowledge being abstract, generalizable and applicable in a range of different situations (Example, Anderson et al., 1996).

Despite these new revelations, Williams' and Wake's (2001) own research, in many ways appeared to support the contention of non-transferability of classroom mathematics (Evans, 2000). Students appeared ill-equipped to use their knowledge of school mathematics to understand workplace practices (Williams and Wake, 2001). Further findings suggested that student's mathematical competence was very much situated in a school culture that values technical competence with well-defined procedures for solving problems in familiar and often mathematical settings. This particular genre of mathematics appeared not well suited to support *t*ransferability or transformation, of mathematics into unfamiliar settings (Wake, 2005). 'Students were found ill-equipped to understand how workers were using mathematics in relation to their day-to-day work' (Wake, 2011, p. 2)

Knowledge is often crystallised (example, Hutchins, 1995) in artefacts, including tools and signs, often as a result of reification (made more concrete or real) by workplace communities (Wenger, 1998).

Use of mathematics is often 'black-boxed' (Williams and Wake, 2007, p. 321) and engagement with mathematics often only occurs at "breakdown" moments. 'The fusion of mathematical signs (in the sense of Pierce), with the reality they represent, reduces cognitive' (Wake, 2011, p. 3). In other words, employees are not required to perform manually the required algorithm for specific mathematical problems. The algorithms are performed by technological devises embedded within the tools. Wake (2011, p. 3) argues that:

School mathematics is just one genre of mathematics and should be recognised as such; with attention being drawn to the diversity of ways in which mathematics might appear elsewhere. This suggests that it is important to focus clearly on key mathematical concepts and principle; for students to experience how these can be applied in a variety of different situations using a range of different notations, inscriptions and so on. Mathematics is used in a rich variety of contexts both in places and more generally in communicating information in all walks of life. These contexts are often complex and detailed, although often simplified to allow mathematical analysis.

The catalyst to this research was the allegation made by employers of school leavers being inappropriately prepared for the workplace. Wake (2011, p.3) goes on to argue that:

> *Workers were often so immersed in their practice that the mathematics became "fused" with the workplace reality it modelled. That underpinning assumptions were not made explicit but workers fully understood how a change in these would have affected outcomes in terms of workplace processes.*

Quintessential to the operation of the school's formal education programme is a curriculum, which contains the content of each subject to be taught. Generally this role has been spoken of in educational circles in Antigua and Barbuda as being synonymous to that of a shopping list. Therefore one expects to find the tenets for an education system to allow for the appropriate preparation of students for living in an economy governed by trappings of the 21st Century and beyond. Hence the 'Mathematics curricula should allow time and space for students to experience using their developing mathematical knowledge, skills and understanding in increasingly complex situations' (Wake, 2011, p. 3). In Antigua and Barbuda things are as described by Wake:

> *Students appear armed with competences in relation to mathematics that see them particularly inadequately prepared to engage in using mathematics in workplaces. Particularly important in this regard is their lack of skills in making sense of the "mathematics of others". This is something that many workers have to do, given that they often take over parts of the work process that have previously been established. Research conducted by William and Wake (2007) pointed to a number of strategies useful in this regard (Wake 2007) and these should be highlighted in curriculum specification (Wake, 2011, p. 3).*

Notably, in earlier research, Wake and Williams (2001) identified seven general mathematical competencies that should be a part of school leavers' graduation package. For example, interpreting large data sets, costing a project, each of which are regular fixtures for the job market across different workplaces should be two of the required competencies.

Fundamental to these is the expectation that technology is an integral tool when mathematics is being applied (Wake 2011). Therefore students would be provided with the knowledge to cope with the *Techno Mathematic*al *Literacies* operations in their work places. This is mirrored in other recent research that identified and organised mathematics around techno mathematical literacies (see Hoyles, Noss, Richards, Kent and Bakker, 2010; Bakker 2009).

Wake (2011, p. 3) argues that 'curricula should provide students with experiences of working with mathematics in complex situations that mirror such scenarios with particular attention being paid to interpretation, variation and adaptation of models'. If school had been part of the workplace preparation simulating and modelling of real world scenarios should have been part of the school's mathematics programme.

3.8 Appropriate Preparation: Australian School Leavers

During the emergence of the new workplace, Zevenbergen and Zevenbergen (1999) reports on the intergenerational differences many social researchers have been noting. Where once the expectation was for offspring to follow in footsteps of parents and to take up jobs in the same industries and worksites this is no longer the norm. Mackay (2004) argues that the intergenerational changes are a reflection of changing social conditions.

In other workplace literature, it has been similarly noted that the changes within the wider society and work brought about largely by the emergence of technology, have created changed work patterns and opportunities (Rinehart, 2001; Rothman, 1998). In the area of numeracy, different demands of workers and workplaces in *New Times* have been observed (Zevenbergen, 2004).

Zevenbergen and Zevenbergen (1999) showcase several case studies from a number of workplaces chiefly to discuss what numeracies are needed for working in contemporary times. Are these different or similar to the knowledge and skills developed through schooling (Zevenbergen and Zevenbergen, 2004)? Researchers hoped that answers to these questions would facilitate a more comprehensive understanding of how young people are best prepared for lives beyond school (Zevenbergen and Zevenbergen, 2004).

Underpinning the main argument advanced by Wake (2011) and Williams and Wake (2000) is employer's claim that school leavers are inappropriately prepared for the mathematics at the workplace. This proposition has not gone unchallenged, for an alternative view is taken by Zevenbergen (2011) who sought to challenge the myths of school leavers being unable to handle the mathematics at the workplace. Focusing on *intergenerational tensions:*

> *Used to frame the ways in which social conditions created different opportunities for young people to develop particular dispositions and views of the world. This was juxtaposed with the theoretical framing offered by Pierre Bourdieu (1977a). Thus drawing on his comprehensive theoretical position, it was proposed that young people created a particular habitus as a consequence of living in particular fields or social spheres. This habitus provided the lens for viewing and acting within the social world (Bourdieu, 1977a, p. 72).*

In Zevenbergen's (2011) view the 'social worlds that were the focus of this discussion were seen collectively as the world of work and by examining the ways in which young people participated in these field of work, a theory of their mathematical habitus was drawn out' (Zevenbergen, 2011, p. 88). The proposition offered by Zevenbergen is that 'young people had developed novel ways of working in relation to numeracy, which are often different from those of past generations' (Zevenbergen, 2011, p. 88). The differences in approaches are attributed to 'the changing social worlds, where digital technologies have radically changed work practices in the past 20 years' (Zevenbergen, 2011, p. 88).

> *The changes brought about by innovations in digital technologies, in the latter parts of the twentieth century had an impact on every aspect of our daily lives, including the workplace. For young people, such technologies were a part of their world and have significantly shaped their ways of working and thinking (Zevenbergen, 2011, p. 88).*

Yet another claim is that 'in terms of mathematics teaching and learning the changes brought about through technology may arguably be slow, but they are evident' (Zevenbergen, 2011, p. 88). This is as claimed by Zevenbergen (2011) manifested and exemplified by the fact that:

Slide rule and logarithmic tables used through to the 1970s are now a memory for many learners and teachers of that era, having been replaced by various electronic devices: calculators, scientific calculators, graphing calculators through to computers (Zevenbergen, 2011, p. 88).

Young people now entering the workplace have grown up in times where they perceive themselves as expendable commodities; these perceptions are the result of an insidious economic rationalist discourse that had pervaded much workplace reform for the past two decades or more. Therefore, for young people, the reality of work is one in which they would have a number of careers over their life span, where part-time, [ordinary] work is common place and where self-employment is a growing phenomenon (Zevenbergen, 2011, p. 88).

Zevenbergen (2011) perceives this as contrary to their Baby Boomer parents, who were more likely to remain in one job for a significant part of their lives (Mackay, 1997). Thus as argued by Zevenbergen (2011, p. 88):

These differences of experience created new possibilities for thinking and for seeing the world of work for young people, which may conflict with that of older generations, for whom life offered alternative experiences and opportunities. Collectively, these different world experiences created different habitus – forming possibilities.

Prensky's (2001, p. 88) position is that:

The impact of digital tools had shaped this later generation in ways that had not been possible for previous generation. His argument aligned with the discourse on post- industrial societies. Today, many parts of industry have recognized the new habitus of young workers entering the world of work and have seen the need of changing current practices.

For digital immigrants, Baby Boomers and generation X, coming to learn about and through digital media was akin to learning a second language. Although it was possible it did not come naturally and needed considerable work. These very different worlds had created very different habitus for digital natives and digital immigrants, in terms of their relationship with digital technologies (Zevenbergen, 2011, p. 89).

This is the context within which the work of Bourdieu (1977a) was most useful in theorising the ways in which social conditions - the field – provided different opportunities for shaping the habitus (Zevenbergen, 2011, p. 89). For Bourdieu (1977a) this was seen as capital. Such capital could come in many forms: cultural; symbolic; social; institutional and economic. Collectively, these concepts allowed for a rich theorization of the world of work and how particular mathematical may create new opportunities for workers, but within the constraints of the field.

3.9 Summary

In this chapter, I present the literature review. The role of some components to include: technology, black boxes, mathematics in different settings and the contentious issue of non-transferability of classroom mathematics to the workplace provide the backbone to this discussion. Additionally, arguments for and against the appropriate preparation of young school leavers for the workplace are featured.

Chapter 4 - Theoretical Framework

4.1 Overview

In this chapter I present the theoretical framework underpinning my research. This theoretical framework comprises several components of the Engeström (2001) second generation Cultural Historical Activity Theory (CHAT) model. These components were chosen specifically because of their capacity to identify the areas of my practice in need of change. Additionally, there are components of the theory which allow me to identify the role of each participant with precision (Triangular configuration).

On the contrary, since my research is being carried out in the field of education and my main role is supervision of teachers and colleagues most of my data comprise conversation and responses to questions. Therefore, the need for a tool to analyse the meaning of conversations becomes pertinent. One such tool/component from the theory is therefore a necessary choice. I am aware that the activity tool is flexible (Daniel and Engeström) and could be adjusted to accommodate one's environment or the purpose for which it is selected. The specific components which I utilize include:

(i) The five principles on which the conceptual frame work of the activity theory is based.

(ii) The elements of the Engeström (2001) second generation model for activity theory.

(iii) Contradictions, a tool used in the activity theory discourse to identify areas in need of change in a system.

These three components are properties of the activity theory framework which plays a role in my research. A brief historical account of activity theory is given during my preliminary introduction, to situate the components in the field. I describe their properties, their roles and their affiliation with my research. Additionally, these components perform a dual role in my research since the function also includes the role of the analytical tool for my data analysis.

Information in this chapter is presented under the captions: (i) introduction; (ii) Engeström (2001) second generation Cultural Historical Activity Theory (CHAT); (iii) constituents of Engeström (2001) version of activity theory; (iv) building an activity system to represent mathematics education in Antigua and Barbuda; (v) contradictions and (vi) summary.

4.2 Introduction: Elements of a Theoretical Framework

This section provides information focusing on the theoretical framework for this research. The theoretical underpinning is a very important component of any research. In my study the main focus is what happens to students at the end of secondary education, who enter directly into the job market, where mathematical activities are part of daily work. In relation to a theoretical framework my position is reflected in the following argument:

> *A theoretical framework is a collection of interrelated concepts, like a theory but not necessarily so well worked–out. A theoretical framework guides the research, determining how the data will be analysed. Theoretical frameworks are important in exploratory studies, where one really does not know much about what is going on, and is trying to learn more. Two reasons could be advanced why theoretical frameworks are important here. First, no matter how little is known about a topic, and how unbiased one thinks one is, it is impossible for human being not to have preconceived notions, even if they are of a very general nature. Second, not knowing what one's real framework is can be a problem. The framework tends to guide what one notices in an organisation, and what one does not notice. In other words, one does not even notice things that don't fit into one's framework! It has been propounded that one can never completely get around this problem, but one can reduce the problem considerably by simply making one's implicit framework explicit (Borgatti, 1996-8).*

In my research where the investigation focuses on whether in the secondary schools of Antigua and Barbuda school leavers are appropriately prepared for the mathematics informing routines in the workplace, the theoretical framework chosen to perform the functions mentioned in the quote above, is the Engeström (2001) second generation CHAT Model of Activity theory.

4.3 Activity Theory: Origins

Although only ‘accepted in 1986 into the research community as an established framework’ (Shames, 1989, p. 54), activity theory has been claimed widely to be a very valuable framework for research where institutions of learning, organisations and workplaces are the prime foci. While many have written on the subject from different angles my preferred version is that of Engeström (2001) since seemingly the work of other scholars in the field are underpinned by his view. Engeström (1999) observed that activity theory is distinctive in three ways:

> *First activity theory is deeply contextual and oriented at understanding historically specific local practices, their objects, mediating artefacts, and social organization (Cole & Engeström, 1993).*
>
> *Second activity is based on a dialectical theory of knowledge and thinking, focused on the creative potential in human cognition (Davydov, 1988; Ilyenkov, 1977);*
>
> *Third, activity theory is a developmental theory that seeks to explain and influence qualitative changes in human practices overtime (Engeström, 1999, pp. 377-378).*

These observations make this framework ideal for my study focusing on whether or not practices employed by teachers preparing students for workplace mathematics are in need of change; or on the other hand whether current practices are adequate for the task of preparing school leavers for the mathematics in the workplaces of the twenty first century.

In giving credence to activity theory as having its root in Marx’s doctrine, Engeström, Miettinen, & Punamaki (2003, p. 3) claimed that:

> *It is not an exaggeration to say that Marx in his Theses on Feuerbach was the first philosopher to explicate pointedly the theoretical and methodological core of the concept of activity.*
>
> *Marx showed that the concept of activity opened up a new way to understand change. Change is not brought about from above, nor is it reducible to purely individual self-change of subjects. The key is "revolutionary practice" which is not to be understood in narrowly political terms but as joint "practical-critical activity, potentially embedded in any mundane everyday practice.*

This statement resonates with my purpose for this research. Indeed as the mathematics officer responsible for mathematics education in Antigua & Barbuda I have always been sceptical of consultants employed by my government to provide suggestions to existing problems in the teaching of mathematics. This framework provides an avenue for me to signpost probable suggestions to perceive problematic areas in my indigenous practice where change is required. But although activity theory had its foundation in the Marxist doctrine, since the version for this research is predicated on the Engeström (2001) model, I will not explore any in depth discourse on Marxism; literature provided by Avis (2007) speaks to the subject of Engeström distancing himself from the Marxist philosophy, since Engeström (1996) wanted to emphasise the point that activity theory was a human mediated activity.

The following reason was advanced by Avis (2007) for parting of ways by Engeström (1996) with the Marxist doctrine:

> *The Marxist conception of socioeconomic formation is often misinterpreted as a doctrine of a mechanically predetermined course of history. Marx and Engels saw it otherwise. 'History does nothing; it "wages no battles". It is man, real living man who does all that, who possesses and fights; "history" is not as it were, a person apart, using man as a means to achieve its own aims; history is nothing but the activity of man pursuing his aims (Marx & Engels, 1975, p. 93 cited in Engeström, 1996, p. 69).*
>
> *By distancing himself from a determinist Marxism, Engeström seeks to emphasise the importance of human agency in activity systems, which is understood as neither deterministically nor mechanistically shaped (Gewirtz & Cribb, 2003, p. 247 cited in Avis 2007, p. 162).*

The information implicit in this quotation is significant since in the schools of Antigua and Barbuda, each student has it within himself/herself to become whatever he aspires to be. Hence, Engeström by this act of elimination of these characteristics has ensured that the present frame work would be applicable for this research. Further support for the use of this framework for my research is to be found in a statement made by Engeström (1990). This statement declares: 'our research did not aim at producing analytical academic reports only. It aimed at grasping developmental potential and dynamics by initiating, supporting, and recording qualitative changes in the practical work activity itself' (p. 72).

This remark goes to the very core of what I hope to gain from this research. Indeed it is my hope that at the end of this research, my findings would play a significant role while informing policy for the way forward in teaching and in learning of mathematics in the schools of Antigua and Barbuda. Certainly my aim is not one of producing a document for the shelves because of its status of being an analytical academic report. My goal is to produce a utilitarian report that will be in the schools and in the classrooms of Antigua and Barbuda where mathematics is taught; performing the role of facilitator for practices of teachers; informing policy; while filling a gap in the literature in the field of classroom and workplace mathematics: having brought a Caribbean perspective to the debate.

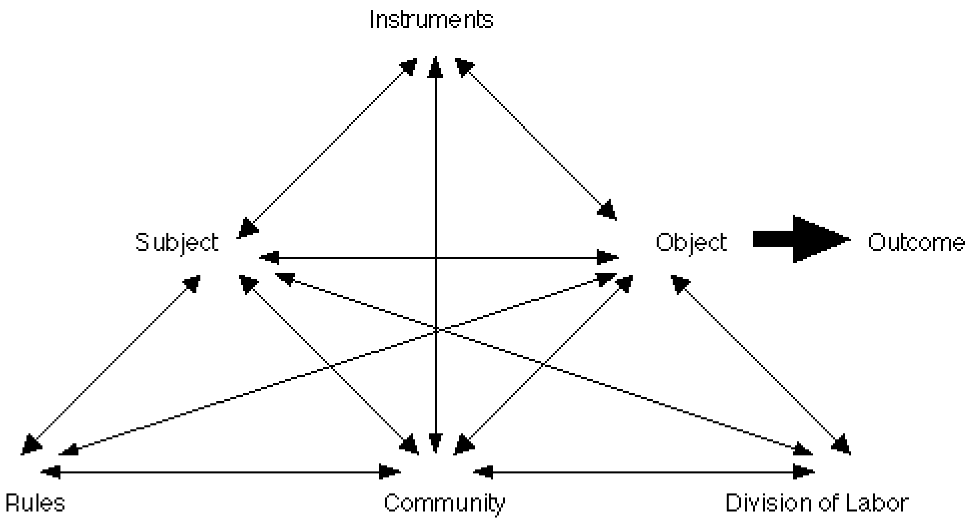
4.4 Engeström's Second Generation CHAT Model

Engeström's (2001) modification of Vygostky's (1981) original theory provides for two additional units of analysis. These units of analysis have an implicit effect on work activities. The first is rules, which are sets of conditions that help to determine how and why individuals may act. These rules are a result of social conditioning. The second is division of labour. Division of labour provides for the distribution of actions and operations among a community of workers. These, two elements provide another dimension of analysis known as community.

The teaching of mathematics in Antigua and Barbuda's secondary schools is controlled by a strong central administrative structure. Here the reliance on rules and the elaboration of an organisational structure with a well-functioning allocation of labour are crucial for the effective functioning of the system. Analysing the rules, many of which were developed during colonial times, when British administrators with a different cultural background formulated these rules, was an important analytical component of this research. History, cultural transformation, the development of the rules, and the organisation of mathematics education over time were important considerations too.

Engeström (2001) brought all the pieces of activity theory development together in the development of his cultural historical activity theory model. In his model he conceptualized an activity system as follows:

Figure 4: Model of an Activity System (Engeström, 1987, p. 78)



In this model of an activity system: the *Subject* refers to the group that is being analysed. Their objective which is what drives their actions or activities is referred to as the object. Mediation of human objectives is done through instruments or tools. These instruments or tools could be either external or internal psychological tools or artefacts. Working groups, department, division teams, or project teams who share the same objectives are referred to as a community. Engeström (2001) breaks down bureaucracies into its various components: 'rules which regulate actions and interactions within an activity system; division of labour, power, and status - both hierarchically and horizontally among workers, within an activity system' (Hooker, 2009, p. 2).

4.5 Constituents of Engeström Version of Activity Theory

My readings from the work of scholars in the field (Engeström 1987, 1999, 2000, 2001; Avis 2007, 2009: Shames 2008: Waite 2003; Wilson 2006; Williams and Wake 2002, 2007; Murphy and Rodriguez-Manzanares, 2008) would suggest that there appears to be no distinct step by step method orchestrating the practical application of the activity theory frame work. However, there is a conceptual framework, based on five principles and cited by Engeström (Avis 2009, pp. 158-159). The content below will identify each of the five principles, of this frame work.

The **first principle** is that:

> *A collective, artefact-mediated and object –orientated activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis (Engeström 2001, p. 136).*

For the focus of my research I would use the interpretation of the first principle as saying that the unit of analysis is an artefact-mediated, object-oriented activity system, seen in relation to other activity systems. My activity system is founded upon the mathematics lessons in classrooms in secondary schools in Antigua and Barbuda. This system is seen in relation to activity systems informed by different workplaces where school leavers seek employment. It is within the activity system of employers, that I should be able to arrive at empirical suggestions as to the appropriateness of preparation accorded students to enable them to handle the mathematics in work routines at their different workplaces. My objective is to determine whether or not mathematics taught in the secondary schools of Antigua and Barbuda is appropriately preparing students to pass the annual Caribbean Examination council's secondary mathematics examination: required for matriculation of students for the workforce or for the trajectory of tertiary education. Methods and teaching strategies employed by teachers, test scores, participant's conversations and documents were used as the unit for analysis.

In keeping with the philosophy of activity theory, the basic unit of analysis for my research is an activity. In my research the activity is to teach students mathematics. The goal is that students should learn mathematical concepts to enable them not only to pass an examination, but also to make them rational, logical, and critical thinkers. Additionally, this acquired mathematical knowledge should pave the way for development of autonomous, creative, and innovative individual possessing tenets to create a skill base to facilitate their appropriate preparation for the different workplaces. This preparation could facilitate the contribution of individuals contributing to the national growth, the expansion, the development of the society and the global market. This mathematical training would ensure that when students enter another activity system in the workplace they would be appropriately prepared to handle the mathematics in their daily routines.

The **second principle** is:

> *The multi-voicedness of activity systems…. The division of labour in an activity creates different positions for participants; the participants carry their own diverse histories, and the activity system itself carries multiple layers and strands of history engraved in its artefacts, rules and conventions (Engeström, 2001, p. 136).*

This principle fits the bill for the cliché 'let all ideas contend' (Rhamphal). The work of my organisation is premised upon a multiplicity of views and opinions of individuals working in each system. Division of labour always produces diverse interest, positions and views among workers. In this research I expect the multi-voicedness of the activity system to be highlighted in participants' differing responses to the same questions I will be asking them. This is the mission where I seek to ascertain whether teachers believe that students are appropriately prepared to handle the mathematics in the workplace (Chapter 7).

For while these participants are all pursuing a common objective of teaching students mathematics, I am aware that they have all been socialized differently and bring to the activity system their own views of how the common goal being pursued could be achieved. However all these differing views have got to be seen within the confines of the rules, history, laws, and norms of the specific activity systems of which they are members. Thus consensus and tolerance are factors that play a crucial role in my activity systems.

The **third principle:**

> *…Is historicity. Activity systems take shape and get transformed over lengthy periods of time…. History itself needs to be studied as local history of the activity and its objects, and as history of the theoretical ideas and tools that have shaped the activity (Engeström, 2001, p. 136).*

The principle of historicity implies that in order to understand the activity system in question, I have to analyse and understand the development of the 'theoretical ideas and tools that have shaped activity' – that is, how it got to be the way it is at the point at which I study it. This I achieved in Chapter 2. This third principle governs the analysis for the main research question: given the increase in technological knowledge (see Chapter 8).

The ***fourth principle:***

> *Is the central role of contradiction as sources of change and development? Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between activity systems. The primary contradiction of activities in capitalism is that between the use and exchange - value of commodities……. Activities are open systems. When an activity system adopts a new element from outside…. it often leads to an aggravated secondary contradiction where some old element…….collides with the new one. Such contradictions generate disturbances and conflicts but also innovative attempts to change the activity (Avis, 2009, p. 159).*
>
> *Individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potential embedded in the everyday actions' (Engeström, 2001, p. 137).*

In my research contradictions are being used to help in identification of areas in the context of my practice in need of change. Identification of areas in need of change in the context of my work will be achieved by using four components with their definitions to analyse conversational data from participants and placing them in respective categories to determine the magnitude and nature of the change (see Chapters 6, 7, and 8).

The **fifth principle** proclaims:

The possibility of expansive transformation in Activity systems [allows for the changes that one seeks to accomplish]. Activity systems move through relatively long cycles of qualitative transformations. As the contradictions of an activity system are aggravated, some individual participants begin to question and deviate from its established norms. In some cases this escalates into collaborative envisioning and as deliberate collective change effort. A full cycle of expansive transformation… is the distance between the present days every day actions of the organization (Engeström, 2001, p. 137).

This is so important to my research which is being conducted not only to construct knowledge but also to inform policy makers of the probable changes required in the mathematics education system. The ultimate question I am seeking to use my research question for which to provide suggestions asks: is there a need for a productive activity of teaching relevant mathematics lessons that could provide students with skills, knowledge, and training that could parallel the requirements of a 21st Century knowledge based economy? The analysis of the data could provide suggestions to this question. In fact, this principle probably could help with provision of suggestions, as I pursue my mission to revolutionize mathematics education in Antigua and Barbuda.

Additionally, the **fourth and fifth principles** are significant:

As they point towards the mechanisms through which activity systems transform overtime. This process is closely aligned with Engeström's concept of expansive learning which arises through the resolution of contradictions. It emerges from processes of questioning, where participants in an activity system or cluster of systems question current practices, ultimately moving beyond these to generate new conceptualisations and forms of practice (Engeström 2001, p. 137).

These five principles constituting collectively the conceptual frame work for the activity theory, which will be used in the analysis of my data, have demonstrated that tenets forming part of its composition have the capacity to guide my research (third principle) while simultaneously to determine how the data will be analysed (Chapters 6,7,8, principle four).

It has also given me the confidence to expect that at the end of my investigation, having started from a position of knowing some of what is involved in the teaching and learning of mathematics in the secondary classrooms of Antigua and Barbuda, at the end of this research exercise I should be in a position to acquire a more in-depth view of what really are the areas for changes in the practices of teaching and of learning classroom mathematics. I have no doubt that as a consequence of these five principles collectively forming the conceptual framework of the activity theory, that I will be able on reflection of events at my research sites, to differentiate between pertinent issues to my research question, when contrasted with irrelevant issues.

My summation of roles for each of the five principles of this framework declares that the ***first principle*** could be seen as setting parameters for characteristics of participants in the research exercise; the ***second principle*** demanding that participants be governed on democratic principles whilst in the execution of one's organisational activities. Therefore, laws, norms and rules of the society should be respected; the **third principle** gives direction for procedural matters in the execution of the investigation; while the **fourth principle** identifies the tenet that would be responsible for changes to be made to the organisation's operations. Finally, **fifth principle** provides the researcher with another component to guide the procedural operations in bringing about any demanded change(s). This component is known as the expansive transformation cycle.

The use of expansive learning has been justified by Engeström & Kerosuo (2007, pp. 336-337) while claiming that:

> *Activity theoretical studies put an emphasis on the object; that is, what is done and learned together in inter-organizational networks, instead of studying only connections and collaboration of networks. The theory of expansive learning enables a longitudinal and rich analysis of inter-organisational learning and makes a specific contribution in outlining the historical transformation of work and organisations by using observational as well as interventionist designs in studies of work and organisation.*

Any device that could be of value to my change process will be welcomed by me. The five principles providing foundation for the conceptual framework of this activity theory are therefore in accordance with my expectation for using it as a tool for analysis of my data collected from research exercise. To assist in the analysis of the collected data from the research another facet to the activity theory frame work will be employed. At the moment a composition of the framework based on five principles has been given.

However, there is more to the framework. In fact it was the view of Engeström (2007) that the frame work was now in its third generation. The second generation and its constituents played a pivotal role in my data collection and data analysis exercises.

The researcher using this framework has been accorded a mechanism to help in identification of the necessity for change within organisations based on the existence of contradictions. The user of the frame work is assured of clarity in meaning of the term contradiction from Engeström's citation of a definition as a source of change and development of something new (Engeström.).

Consequently, having made the distinction between the terms contradiction, disturbances/problems, as the researcher in this exercise, there is no doubt in my mind concerning the correct decision having been made in using this frame work. The benefit resided in its ability of allowing me to identify the contradictions that may be found in my activity systems from my data collection exercise.

Hence this inbuilt mechanism, acting in the role of a signpost while signalling the need for changes or against changes based on the presence of or absence of contradictions makes this conceptual framework, a valuable apparatus during the executing of my research exercises in workplaces and institutions of learning.

Especially when from the readings I have done, it is clear, that generally, it is very difficult to carry out research in learning institutions since learning is such an individualistic process; and where the question 'what is learning?' Has different interpretations for different people, it makes this mechanism even more valuable to the frame work. The value is even more profound when one realises that as a result of this mechanism it gives the research much needed properties of transparency, trustworthiness, reliability and validity of the research findings; once the correct interpretations would have been accorded the analysis of the collected data.

4.6 Building an Activity System to Represent Mathematics Education

Examination of the mathematics education system in Antigua and Barbuda indicated that it could have been represented by the following mathematics activity system (Figure 4.5). This activity system was utilised as the basic unit of analysis. The components were:

1. *Subjects*: the education policy makers, teachers, students, and employers comprised the primary subjects in this activity system. It was this group that had as its objective quality performance in mathematics.
2. *Objects or objective*: training students to be competent in mathematics as measured by Caribbean Examination Council's Caribbean Secondary Education Certificate (CSEC) Mathematics Examination. Simultaneously, students should be capable of performing successfully in the workplace.
3. *Tools:* included education budget, mathematics curriculum, training, technology, books, work attachment, school infrastructure, management systems, including payment and, incentive system conflict resolution, and career path.
4. *Rules*: included the bureaucratic rules governing employment with the Ministry of Education, union contracts, Education Act 2008, school-based rules, and job attachments rules.
5. *Community*: Parents, political directorate, educational interest groups, and the general public.
6. *Division of Labour*: hierarchical system of policy makers, education ministry officials, school principals, employers and students.
7. *Outcome*: students pass CSEC mathematics and are competent on the job.

4.7 Contradictions

Contradiction is a foundational philosophical concept that should not be equated with paradox, tension, inconsistency, conflict, dilemma or double bind since these were rather manifestations of contradictions and not synonyms. In organisational change efforts and interventions, contradictions were to a large extent manifested in discourses (Engeström.). But in the absence of any systematic frameworks to identify the manifestations of contradictions in discourses the following tool was constructed (Engeström.) to fill the gap. This tool is depicted in Table 4.1

The Table 4.1 comprises four kinds of discursive manifestations, features, their typical linguistic cues and resolutions. These are variables that I use to identify contradictions in the conversation of my participants in the analysis of the data in Chapters 6, 7, and 8.

Table 4.1: Discursive manifestations and their typical linguistic cues

Manifestation	Features	Linguistic Cues	Resolution
Double Bind	Facing pressing and equally unacceptable alternatives in an activity system	**"**We', "we must", "we have to". Pressing rhetorical questions, of helplessness. "let us do that" "We will make **it"**	Practical transformation (going beyond words)
Critical conflict	Facing contradictory motives in social interaction, feeling violated or guilty	Personal, emotional, moral accounts. "I now realized that….	Finding new personal sense, and negotiating a new meaning.
Conflict	Arguing, criticizing.	'"No", " I disagree" "this is not true". " Yes", this I can accept"	Finding a compromise. Submitting to authority or majority.
Dilemma	Expression or exchange of incompatible evaluation.	"On the one hand ", ' on the other hand',", yes, but, " " I didn't mean that". " I actually meant"	Denial , Reformulation

4.8 Summary

This chapter presents information for the theoretical framework of my research. I draw on components of the Engeström's (2001) second generation Cultural Historical Activity Theory (CHAT). I use several headings to describe the properties of the components and offer reasons for using them as the analytical tool and theoretical framework of my research. The salient point is that my choice is based on the fact that this is a tool designed to deal with educational matters directly related to my research. Finally I make the link between mathematics lessons and the activity systems forming part of my practice.

Chapter 5 - Methodology

5.1 Overview

In this chapter I present the method and the tools used in addressing my research questions. I also address ethical issues. Additionally, I provide information on the tools used to analyse the data.

5.2 Introduction

In this section I introduce the statement of the problem, how the study was executed, the research question and the analytical tool. In Antigua and Barbuda, mathematical abilities and potential of students are seemingly only recognised and valued if students are seen to be successful in passing an examination at the end of secondary schooling. However, the subsequent demands of mathematics in the workplace and its correlation to the mathematics taught in schools have not been specifically researched.

Therefore, in order to explore the claim made by employers that students are not appropriately prepared for the job market and by implication the mathematics at the workplaces, this research is being undertaken to examine the relevance of the content of the Caribbean Examination Secondary mathematics curriculum used in the secondary schools of Antigua and Barbuda to prepare students to handle appropriately mathematics in workplaces informed by technological knowledge, technological tools and high level skilled operations.

Hence, the main focus of this research is that of learning and recording what happens at the end of secondary education to students entering into the job market where mathematical activities are part of daily routine. The research is governed by the research question: *given the increase in technological tools in the labour market of Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the workplace?* The methodology I used is the interpretive constructionist paradigm. The method is premised on the qualitative paradigm. My tools for the collection of data are interviews, structured conversations, observations, participatory observations, telephones, laptop, computers, cameras, tape recorders, and email. There are a total of approximately one hundred and eighty participants from various sectors of the economy to include schools, policy makers from the Ministry of Education, employers and employees from the labour force. The theoretical framework of the research is the Engeström's (2001) Cultural Historical Activity Theory (CHAT) model as discussed in Chapter 4. Thus following the methodology, several data collection tools, applicable to the types of data sought and appropriate for the subsequent analysis of the said data are used.

5.3 Epistemology

This section introduces the epistemological underpinning of my research. Epistemology deals with 'the nature of knowledge, its possibility, scope and general basis' (Hamlyn, 1995, p. 242). For Maynard (1994, p. 10) 'epistemology is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate'. The directional relationship between ontology, epistemology, methodology, methods and data sources assisted me in my research by allowing me to understand how a particular view of the world affected the whole research process and our interpretation of it.

Hence by setting out the interrelationship between what 'I think could be researched (my ontological position); linking it to what I could know about it (my epistemological position) and how to go about acquiring data (my methodological approach), I could begin to understand the impact of my ontological position on what and how I could decide to execute my research' (Grix, 2004, p.65). The **Figure (5.1)** below depicts the interrelationship between the building blocks that were adopted for this research. The first two rows have been adopted from Grix (2004, p. 66) and the third row situates my research in the paradigm.

Figure 5: Interrelationship between the building blocks of research

Ontology	Epistemology	Methodology	Methods	Tools	Sources
What's out there to know?	What and how can we know about it?	How can we go about acquiring that knowledge?	Which precise procedure can we use to acquire it?	What means are best fit for purpose?	Which data can we collect?
Is the mathematical curriculum used in the secondary schools of Antigua and Barbuda appropriately preparing school leavers for the workplace?	Social constructionist One of constructing new knowledge working as a member of a collective in the context in which I work.	Interpretive	Qualitative	Interviews, structured conversations, video, cameras, print and electronic media, documents, emails, gatekeepers, photographs.	Discourses from participants, documentary records and photographs.

There were several reasons for wanting to have a clear and transparent knowledge of the ontological and epistemological assumptions that underpinned my research:

> *First, to understand the interrelationship of the key components of research (including methodology and method);*
>
> *Second to avoid confusion when discussing theoretical debates and approaches to social phenomena whilst executing the research;*
>
> *Third to recognise others' positions in executing their research and to defend my position while conducting my research (Grix, 2004, p. 57)*

Knowledge of these reasons is significant in my research, since it is important for me to understand the interrelationship between the philosophical paradigms underpinning my research and how the properties of one impacted the other. This involved ensuring that in the execution of my research there was a correlation between the method and the tools to the methodological paradigm governing the research. This synergy is important to ensure the creditability and reliability of my research. Additionally, it is important for me to understand that there are several angles from which to investigate identical social phenomena. However, my choice should always be based on the principle of most appropriate for my specific context.

The fact that my research is in an educational field made the discussion of ontology and epistemology particularly important as argued by Packer and Goicoecha (2000, p. 227) who claim:

> *Education was not only epistemological but also ontological. When students learned subject matter, they did more than changed their cognitive states. They also became different kinds of people – the kinds of people who thought about the subject matter in that way, who engaged in the cognitive practices required to learn as the school teaches. Schools favoured one set of cognitive practices and this tended to produce a kind of person who, for example, favoured decontextualized knowledge over knowledge embedded in craft and apprenticeship activities. Schooling was not just about cognitive development, but also about the construction of persons. The ontological character of education meant that, when students learned things in school, both academic learning and the construction of individual identities occurred.*

Hence the educational context is implicated in the moulding of individuals whose trajectory I am exploring. This is central to my exploration of conflict between learning mathematics in two contexts. On the other hand, my research is being undertaken to provide suggestions that could inform policies in the mathematics education process.

A further view of constructionist is advanced by Crotty (2006, p. 9) who claims that:

> *There was no objective truth waiting for us to discover (as advanced by the Objectivism paradigm). Truth or meaning came into existence in and out of our engagement with the realities in our world. There was no meaning without a mind. Meaning was not discovered but constructed.*

This also is a view I embraced. Additionally, I support the view that 'different people may have constructed meaning in different ways even in relation to the same phenomenon' (Crotty, 2006, p. 9) and that, therefore, in 'this view of things, subject and object emerged as partners in generation of meaning' (Crotty, 2006, p. 9). This is a view that resonated with the theoretical frame work of this research (see Chapter 4).

It is a view embedded in the second principle of the Engestrom's (2001) Cultural Historical Activity Theory (CHAT) frame work: that of multi-voicedness borne out of the collectivist property of the first principle (according the preference for the status of a collective subject as one of the components in an activity system). Therefore, instead of accepting the views of one factor as foundation to most decisions, the preference generally was for a collective view to be amalgamated into the unified view. This is the concept governing team work and tolerance among students in schools of Antigua and Barbuda.

5.4 Methodology

This section introduces my methodological choice, research questions, my data collection strategies, qualitative method and sources of evidence.

5.4.1 Choice of Methodology

The methodology I used is the interpretive qualitative paradigm. My methodological choice is based on what I thought was the best paradigm for my research. My research, 'involved people in social settings, multiple perspectives and interpretations [were] almost inevitable' (Opie, 2007, p. 15).

Since I know that my research takes place in the context in which my participants work, that factor underpinned my eventual choice of the interpretive qualitative paradigm to govern my methodology. From my readings on methodology I learnt that in carrying out an exercise of deriving new knowledge to inform and to make changes in my present professional practice, it is the methodology that ensures that I achieve that goal:

> *Methodology referred to the theory of getting knowledge, to the consideration of the best ways, methods, or procedures, by which data that would have provided the evidence basis for the construction of knowledge, about whatever was being researched was obtained. Methodology was concerned with the description and analysis of research methods rather than with actual, practical use of those methods. Methodological work was, therefore, philosophical, thinking, work (Opie, 2007, 16).*

Hence I was determined to make my methodological choice justify Opie's claim. It was at this juncture that I foregrounded my ontological and epistemological position, since I knew that my beliefs played a leading role in the epistemological underpinning of my research and subsequently impinged on my methodological choice.

> *Usually, the most significant factor that influenced choice and use of methodology procedures was where the researcher was coming from in terms of [her] philosophical position and [her] fundamental assumptions concerning:*
>
> *Social reality – her ontological assumptions;*
>
> *The nature of knowledge of her epistemological assumptions;*
>
> *Human nature and agency – specifically her assumptions about the way in which human beings related to and interacted with their environment (Opie, 2007, p. 18).*

My ontological position of a relativist resonated with my belief that:

> *There was no objective truth waiting for us to discover it. Truth or meaning came into existence in and out of our engagement with realities in our world. There was no meaning without a mind. Meaning was not discovered, but constructed (Crotty, 2006, p. 9).*

Similarly my epistemological position of a social constructionist informs my belief that underpinned my professional role as an educator. It is a belief that takes the view that I should be involved in the creation of knowledge while simultaneously assisting individuals under my supervision to become constructors of knowledge; as they seek solutions to problems in their everyday lives: whether in classrooms, workplaces or in their natural environments. Hence the interpretive paradigm, which asks individuals to interpret and to make sense of phenomena in their environments and subsequently allows me to uncover the meaning to their interpretations, is well within the domain of my beliefs.

It is this interpretive paradigm which provided me with the vision of constructing interview questions to ask participants as I sought suggestions to help in bringing about a change in the way mathematics is taught and learned in classrooms of Antigua and Barbuda. Eventually it will be the interpretations I give to the responses from my participants which will provide information that I will be using as building blocks to help in construction of new suggestions/knowledge to inform mathematics education in Antigua and Barbuda.

5.4.2 Research Questions

The strategies of inquiry chosen in a qualitative research project had a dramatic influence on the procedures, which, even within strategies were anything but uniform. Looking over the landscape of qualitative procedures revealed diverse perspectives ranging from social justice thinking (Denzin and Lincoln, 2005), ideological perspectives (Lather, 1991), philosophical stances (Schwandt, 2000), to systematic procedural guidelines (Creswell, 2007; Corbin and Strauss, 2007). My research fitted into the latter category. I now discuss the nature of the research questions.

> *In qualitative study, inquirers stated research questions not objectives (that is specific goals for the research) or hypotheses (that is predictions that involve variables and statistical test). These research questions assumed [two] forms: a central question and [two] sub-questions (Creswell, 2009, p. 129).*

While my main research question formed the central question in my research, two subsidiary questions are posed to help in the unearthing of information relevant to this main research question (See Chapter 1). The main focus of my research is that of unearthing hidden factors that are in need of changes as I seek to make suggestions to refocus the way mathematics is learned and is taught in Antigua and Barbuda**.**

It is important for my research questions to be appropriate for the purpose. I am also aware that different interpretations could have been accorded the same problem being researched and that there was always the possibility of acquiring far too much data. Thus, although my collection of data utilised several instruments, their utilisation parallels the focus of my research questions.

5.5 Addressing Ethical Issues

This section introduces the premise of ethical issues, ethical issues and researcher's role, ethical guidelines, and addressing ethical issues.

5.5.1 Premise of Ethical Issues

Ethical issues are metaphorically the legal framework informing the conduct upon which my research exercise is performed. While my ontological paradigm influences my epistemological choice and subsequently acted as the factor controlling my methodological choice, it is within my methodological paradigm that components of ethical issues are located. Hence the interrelationship among the paradigms is important not only for roles of allowing my comprehension of their philosophical properties but additionally for ensuring the creditability and dependability of my research.

The methodological paradigm could also be credited with the responsibility of ensuring that the report is held to the standard of research professional organisations since it is responsible indirectly for the method and subsequently the tools that are used in the execution of the research. I argue that the correlation produce by the union of the method and the tool is the driving force acting as the safety valve informing the high esteem in which the final product of the research is held.

In all my actions, in the execution of this research, I could not ignore the role of my ontological paradigm. It is my ontological position of a relativist which claims that 'there was no objective truth waiting for me to discover it. Rather meaning and truth came into existence in and out of my engagement with realities in the world' (Crotty, 2006, p. 9). This view gives credence to my epistemological position. It is within this process that ethical issues are addressed.

5.5.2 Ethical Issues and Researcher's Role

Ethical issues signposted the roles of my values in my research exercise. It brought into the forum questions to include: how should I treat the participants in my research? Were there activities demanding my drawing a boundary line? These questions also brought to bear on my research the role of professional Associations such as *the British Sociological Association, (BSA); the Social Research Association, (SRA); the British Society of Research Literature in Mathematics (BSRLM); The British Educational Research Association (BERA) and the International Group of Psychology in Mathematics Education (IGPME).* In this research it is *the British Educational Research Association, (BERA)* ethical guidelines for researchers I adopted. Additionally guidelines for ethical conduct for my research are provided by my University's Research Guidelines (see Appendix A).

Arguably how I viewed the social world had implications for the sorts of methodologies and procedures I considered as 'valid' means of collecting 'valid' data that could be used to make a 'valid' interpretation, thus creating 'valid' knowledge' (Opie, 2007, pp. 19-20). My social constructionist epistemological position meant 'collection of subjective accounts and perceptions that could explain how the world was experienced and constructed by the people who lived in it' (Opie, 2007, pp. 19-20). All these processes are bounded up with ethical issues.

My research is about getting 'better knowledge' (Griffiths, 1998, p. 98). As the researcher I do have opinions about what I am researching. These 'opinions give a clue of values' (Griffiths, 1998, p. 129). That is why ethical issues could not be avoided in my research (Robson, 1993; Denzin and Lincoln, 1994; Hitchcock and Hughes, 1995). Values are wrapped up in my morals, my culture, my norms, my laws, and my rules governing my life. Indeed:

> *Ethics underpinning ethical judgement principles could be: an equal respect for and appreciation of every individual; a recognition that persons were constructed and interpreted themselves in relation to power relations in society, and that I had real choices about how to do this; and an understanding that there were no hard and fast rules or certainties to be had; Hence ethical decisions were always judgement in particular context (Griffiths, 1998, p. 134).*

As the researcher I needed to explore my fundamental assumptions relating to ontology, epistemology and human nature and agency because these had major implications for my methodological and procedural choices. These assumptions were not fixed once and for all. Hence they were subjected to changes in the course of my research exercise. I also understood that my honesty was important and 'telling it as it was' could only be in the interest of a creditable research practice' (Opie, 2007, p. 23). This led to my support for Opie's (2007, p.23) views:

> *That researchers who had examined and reflected upon their assumptions and consequent values and who were prepared to make their position explicit, provided themselves with a strong basis on which to design and conduct rigorous work that could justify and which would stand up to scrutiny. They were likely to be well aware of the ethical implications of their work because they would have considered their relationship vis–a-vis the people who may be touched by their research.*

This was the group whose membership I sought. My research was carried out to facilitate improvement within the educational context of my professional life and also by extension for that of my colleagues and the people I supervise. Therefore, being aware of the ethical implications of my research was important since much educational research was by, for, or with people. I had a responsibility to act in an ethical manner. My aim in the execution of this research was not to harm anyone or to act in any unethical manner. I knew that 'research was a political activity since it affected people's lives however slightly and tangentially' (Griffiths, 1998, p. 134).

Additionally, I was aware that the success of my research would have been dependent upon my ability to engage other participants as I sought suggestions for the different perspectives from which I could explore my research questions. Therefore the property embedded in the reflexivity literature became a tool since I understood that 'reflexivity was about relations to oneself' (Griffiths, 1998, p. 134). Nonetheless I was soon to realize that 'reflexivity was not a straight forward business' (Griffiths, 1998, p. 134).

While I knew that I could not be responsible for everything in the research exercise I still needed to know what were the boundaries and limits of my operations. It was important for me to embrace the attribute from the reflexivity literature of never expecting to execute a perfect research: 'perfection was never possible although improvement was' (Griffiths, 1998, p. 134). Nevertheless my goal was to produce a credible, dependable research based on sound ethical principles.

5.5.3 Ethical Guidelines

Generally, the most significant factor that influences choice and use of methodology and procedures was:

> *Where the researcher was coming from in terms of [her] philosophical position and [her] fundamental assumptions concerning social reality – [her] ontological assumptions; the nature of knowledge – [her] epistemological assumptions; human nature and agency – specifically [her] assumptions about the way in which human beings related to and interacted with their environment (Opie, 2007, p. 16).*

Assumptions of this nature are governed by:

Values and beliefs that were based in, political allegiance, religious faith, and experiences that were consequent upon social class, ethnicity, and gender, and sexuality, historical, and geographical location (Opie, 2007, p. 16).

I could not divorce myself from the ethical issues impinging or embedded within my research. My research has no ethical value or issues of its own. Rather these are issues brought into the research process by me.

Ethical values and issues in my research would therefore be a direct result of my personal moral values and biases thus justifying Weber's (1946) claim that 'all research was contaminated to some extent by values of the researcher'(p.65). Only through those values did certain problems get identified and studied in particular ways. In fact the conclusions and implications that were to be drawn from a study, Weber (1946) argued, 'were largely grounded in the moral and political beliefs of the researcher' (p.65).

Additionally, when studying people's behaviour or asking them questions, I not only took my values but also my responsibilities to my participants into consideration. Mason (1996, pp.166-7) discussed two ways in which such ethical issues impinged upon qualitative researcher:

i) The rich and detailed character of much qualitative research could have meant intimate engagement with the public and private lives of individuals.

ii) The changing directions of interest and access during a qualitative study meant that new and unexpected ethical dilemma were likely to arise during the course of [my] research (Silverman, 2008, p.257).

My approach in confronting unexpected ethical issues ranged from deciding what was the purpose of my research (Silverman, 2008); choosing the appropriate individuals and groups that could have provided valuable suggestions for my research questions; to considering what were the implications for my participants from having framed my research topic in the way I did (Mason, 1996).

Instrumental in facilitating and offering clarification with my ethical procedures were the ethical guidelines of my University's School of Education Research Community, and the British Educational Research Association (BERA). Hence decisions I took focusing on ethical issues were predicated on the following eight ethical guidelines from the revised 2008 British Education Research Association's (BERA) Ethical Guideline document. These issues were:

(i) Voluntary Informed Consent

> *It is important for participants to be fully informed of purpose and intentions of findings of the research. Prior to their involvement in the research, [participants] must understand the nature of the research, and the nature of their involvement. They must freely agree to participate (BERA, 2004, pp.5-8).*

Bryman (2008, p.121) saw the 'issue of informed consent in many respects as the area within social research ethics that was mostly hotly debated. The main issue of the debate tended to be either what was variously called disguised or covert observation' (p. 121). Another argument advanced by Bryman (2008) was that 'even when people knew that they were being asked to participate in research, they should be fully informed about the research processes' (p. 121). However, Homan (1991) has observed that 'implementation of the principle of informed consent [was] easier said than done' (p. 73). There were two reasons given for some of the known difficulties:

> *It was extremely difficult to present prospective participants with absolutely all the information that might be required for them to make an informed decision about their involvement.*
>
> *In ethnographic research, the researcher was likely to come into contact with a wide spectrum of people, and ensuring that absolutely everyone had the opportunity for informed consent was not practicable because it would be extremely disruptive in everyday context (Bryman, 2008, p. 121-122).*

This was not an issue for my research which was conducted on a small, geographically located tropical island, with undulating coastline and flat, easy accessible terrain. In my research exercise as will be revealed later in this discourse, consent was sought from all participants on each occasion he/she was being considered as a candidate for my research exercise. Sometimes, once oral consent had been obtained the signing of official consent form took place immediately after the data were collected.

A problem for qualitative researchers: was despite wide spread condemnation of violation of informed consent and the view that covert observation was especially vulnerable to accusations of unethical practice in this regard, from the literature I learned that studies using the method (Fielding, 192; Taylor, 1999) were still appearing periodically. The defence was usually of the 'end-justifies the means' (Bryman, 2008, pp. 128-129). However the principles of informed consent would have been violated. Ideally where informed consent had not been obtained prior to the research it should be obtained post hoc (Bryman, 2008).

(ii) Deception

> *There should be no use of deception or [subterfuge*] to collect data (BERA, 2004, pp.5-8).*

In this research the term deception is defining the situation in which researchers deliberately give false information to participants in order to acquire a particular response. Once 'lied to, participants would be much less likely to give another researcher an interview. Further this could result in tarnishing the reputation of research in general' (Grix, 2004, p.147). This technique was never featured in my research. In fact my hermeneutics paradigm would detect that this would constitute an immoral act (in Christian religious term a 'sin') that could have far reaching repercussions to include losing my place in the eternal kingdom. Hence this could never have been an option for this researcher.

(iii) Right to Withdraw

> *Participants should be advised that they were able to with draw from the study for any or no reason at any time (BERA, 2004, pp.5-8).*

This was a message given to participants within the consent form (see Appendix C).

(iv) Special Protection

> *Children and vulnerable adults were to be specially protected (BERA, 2004, pp.5-8).*

Research that was likely to harm participants was regarded by most people, to include me as unacceptable. 'Harm could entail a number of facets: physical harm; harm to participants' development; loss of self-esteem; stress and 'inducing participants to perform reprehensible acts' as Diener and Crandall (197, p. 19) put it. My research had no intention to cause harm or to cause grievance to any of my participants.

Since contact with my participants involved in the main answering questions, I made certain that during my construction of interview questions, that they were objective, not degrading or compelling my participants to divulge private information. All questions were pitched at a level to focus only on what was in the best interest of improvement of mathematics education and with my research questions in mind; knowing that my only motive was to acquire better suggestions to enhance teaching and learning of mathematics in Antigua and Barbuda. It was not about self but rather about country. Hence 'each endeavouring all achieving' (Richards, 1981), a line from the national anthem of Antigua and Barbuda and the Motto of my country, reminded me that all of us were trying to achieve the same goal. Hence not harm but rather protection for each other should be the hallmark of any action taken either by researcher or the participants. Additionally, mutual respect ensured that protection was offered to all of my participants.

(v) Incentives

> *Incentives if used must be appropriate and must not be used in a way to coerce participation (BERA, 2004, pp.5-8).*

The only form of incentive used by me during my data collection exercise was to guarantee my photographer a meal when lunch time found us still out in the field collecting data. This was a gesture on my part that was not used for coercion, only a humanitarian act.

(vi) Detriment to Participants

The researcher should make known any predictable detriment to participants (BERA, 2004, pp.5-8).

Again like (iv) prospective participants should be apprised by a detailed account of what the research would entail prior to being asked to be a full fledge participant. Hence a clear, transparent explanation of what my research is about and what role I am asking them to perform should give participants the opportunity to weigh the cons and pros of accepting an offer to be one of my participants. See Appendix B confirming that this was done by me when asking for volunteers to be a participant in this research.

(vii) Privacy

The researcher should respect the participants' right to privacy and guarantee confidential anonymous treatment of the participants' data (BERA, 2004, pp.5-8).

This was one area where I felt ethical issues could have presented me with some difficulties despite my best effort to conform to the act. Like many qualitative researchers I concurred with the view that there were particular difficulties for many forms of qualitative research. Whereas in quantitative research it would have been possible to anonymise records and to report findings in no traceable formats, for qualitative research this was not an easy accomplishable task. Especially in small islands where in the labour market one's job could be traced to the specific individual. In my Caribbean country with a population of eighty thousand this was possible. That was why it was important for me to ensure that questions posed to my participants were in no way demoralising to their professional conduct or in any way a source for stress or lowering of self-esteem.

Additional area of concern arose from particular problems in the future with regard to secondary analysis of qualitative data, since it could be difficult though not impossible to present field notes and other associated data in a way that could prevent participants and places from being identified. As Alderson (1990) has suggested, 'the difficulty was one of being able to ensure that the same safe guards concerning confidentiality could be guaranteed when secondary analysts examined these records' (Bryman, 2008, p. 119) as I have provided in my capacity as the original primary researcher. In the future aspects of confidentiality and management of it as found in the United Kingdom's Data Protection Act (1998) will have to be adopted by me into the research practices engaging my attention in the future.

(viii) Disclosure

> *The researcher may have a duty to disclose illegal or harmful behaviour. This must be made clear to the respondent (BERA, 2004, pp.5-8).*

This was never a feature of my research.

5.5.4 Addressing Ethical Issues

Recognising that ethical issues pervaded my entire research exercise and while ensuring that my ethical issues were in keeping with the above guidelines, I began the process of incorporating ethical principles into my research.

Since my research involved collecting data from people and about people (Punch, 2005), I needed to protect my research participants; develop a trust with them; promote the integrity of the research; guard against misconduct and impropriety that might reflect on their organisations or institutions and cope with new, challenging problems (Isreal and Hay, 2006).

Ethical questions were apparent in such issues as personal disclosure, authenticity and credibility of the research report, the role of researchers in cross-cultural contexts and issues of personal privacy through forms of internet data collection (Israel and Hay, 2006). In the literature, ethical issues arose in discussions about codes of professional conduct for researchers and in commentaries about ethical dilemmas and their potential solutions (Punch, 2005). These were matters that I had to take into consideration as I initiated and adopted guidelines to inform the ethical issues in my research.

In my research during the identification of the research problem, care was taken (over a period of thirteen weeks and four days) to identify a problem that would benefit the individuals playing a role in my study, in conjunction with the benefits that should accrue to the economy and the education system of Antigua and Barbuda. Furthermore, the problem was chosen to ensure also that benefits derived from the exercise would be meaningful to others besides me (Punch, 2005).

Similarly, in developing the purpose statement, I ensured that there would be no deception stemming from participants understanding one purpose while I had a different purpose in mind. This was achieved by presenting participants with the goal, aim and objective of my research and explaining why they were being asked to participate in the exercise. The significance and value of their involvement was also revealed to them. In fact my research was sponsored by the Commonwealth Organisation Education Division. Hence the proposal, to include ethical measures for this research had to be approved.

For collection of data further ethical issues had to be in place before getting a clearance from the Ethical Committee of this University and they reviewed my research plan. I also had to construct an informed consent form for participants to register their desire to be a participant in the research (see Appendix C). Where it was necessary to use the professional title for some of the public officers who were participants in the research, permission first was sought (see Appendix for sample). The consent form can be obtained from the database of my research. Further pledge to respect the laws of the country in which the research was executed had to meet the criteria required by the ethics governing body.

To address the ethical issues pertaining to access to study participants at the research sites, a covering letter from my main supervisor was the instrument (see Appendix). It was always my intention to respect the research sites and the culture governing all my research sites. Hence I was prepared to abide by whatever ground rules were set by the owners/managers for my compliance. Additionally, where the possibility presented itself for harm, intimate information was disclosed. I was prepared to apply whatever measures were required to avoid any undue harm to my participants.

Once data collection was completed, I was aware that there could be further ethical issues in data analysis and in interpretation of the data. The anonymity of individuals' roles and incidents in my project has been protected by assigning pseudonyms to some of the places and names of the participants. Where pseudonyms were not assigned was because of my having deemed the information to be already public knowledge. Additionally some persons were adamant that their schools be named. Terms such as transparency were mentioned as to be preferred in contrast to anonymity (participants). I was also aware that data 'once analysed needed to be kept for a reasonable period of time before discarding the said data' (Creswell, 2009, p. 92). In this research the data will be secured in a database. In the interpretation of the data, it is my intention to provide an accurate account of the information.

Additionally, in writing and disseminating of the research, I would not be:

> *Using language or a word that is biased against persons because of: gender, sexual orientation, racial, or ethnic group, disability, or age. Rather I would be aiming to present unbiased language at an appropriate level of specificity; using language that was sensitive to labels and acknowledging participants in my study (Creswell, 2009, p. 92).*

It is my intention to provide a copy of the final research document to the managers at all of my research sites. Finally the details of the research now form part of the content of this thesis; ensuring that readers should be able to determine for themselves the credibility of the study (Newman, 2000; Creswell, 2009).

5.6 Data Collection Strategies

In this section I introduce my research participants, how I gained access to each of my research sites and how I collected data from my participants.

5.6.1 Data Collection Sites

My data were collected at the sites where most of my participants worked. Exceptions to this were: the Minister of Labour; focus group; the President of The Antigua and Barbuda Union of Teachers and the four former Directors of Education. My data were collected from examination of documents, from observations of workers in their workplaces utilising artefacts and kitchen utensils. In addition, from my reading of the workplace literature (Chapter 3) alluding to the mathematics in the workplace being wrapped up in black boxes (Williams and Wake, 2007). Additionally, data were collected from photographs, video, structured and unstructured conversations with participants, interviews, email and telephone calls.

In my research, at times the same instrument was used to collect suggestions from several participants for the same phenomenon. This was used during data collection from: the heads of mathematics departments; the present and the former Directors of Education; the four Zone Officers, the President from the Antigua and Barbuda Union of Teachers and the focus group participants.

5.6.2 Research Participants

To address my research questions I sought information from several participants from the Ministry of Education. These participants were directly connected to the education system as policy makers, curriculum specialists, education officers, supervisors for curriculum matters and teachers in schools; principals, heads of mathematics departments, students, senior teachers in the primary schools and former Directors of Education.

Subsequently other participants included employers and employees at the workplaces designated as research sites for this research. The sites included: one commercial bank, Ministry of Finance: using some participants from the customs department; six hotels, one privately owned power and utility station on the off-shore island of Long Island, Island Services; vendors from the vegetable market, meat market, fish market and craft market. The Ministry of labour, with the Minister of Labour as its participant; a former Financial Secretary and a former Commissioner of Labour completed the list of participants.

The policy makers from the Ministry of Education constitute my category one. Since this ministry is responsible for public education of citizens and their preparations for the workplace my data collection exercise began there. Additionally, as the headquarters of my official workplace, this was the ideal site for gaining access since all participants and policy makers were known to me in a professional capacity. An improvement in the mathematics education programme is a goal shared by all; therefore we are united in our desire for a successful outcome to this research exercise. Hence access to this site was one of convenience. The participants in the category include: The Minister of Education; the Permanent Secretary; the Director of Education, the Assistant Director of Education and four former Directors of Education.

The contribution of this data from the policy makers to this study is justified from the measures they provide to aid my assessment of whether the resources advanced to engage the process of appropriately preparing school leavers for the work place are adequate.

My second category of research sites are the schools. The participants are:

- Four Education Officers, each with supervisory roles for one of the four zones into which the primary schools are divided;
- The Acting Officer Mathematics Education, with specific responsibility for the Primary schools and acting Officer Mathematics with specific responsibility for secondary schools;
- Principals and Heads of Mathematics Departments of Secondary Schools;
- President of the Antigua and Barbuda Union of Teachers;

- Testing and Evaluation Officer;
- Acting Education Officer Secondary schools;
- Some present fifth form students and past students who were now employees.

Finally, documentary evidence was provided from the budget records from the database of the administrative department of the Ministry of Education, the Caribbean Examination Council's mathematics syllabi used in secondary schools and mathematics statistical data from the Ministry of Education's data base.

The contribution from the participants from the schools was used to assess whether the curriculum had appropriately prepared the school leavers for the work place. If it had not, how had it not? And if it had, how had that been achieved?

My third category was workplaces, which were designated as sites for my research. The participants in this category comprised from The Ministry of Finance: several divisions in the Custom's Department.

The hotels: chefs, pastry chefs, heads of housekeeping departments and their assistants, maintenance managers, human and resource managers and trainers of the newly employed at hotels.

The contribution of the workplace participants would come from their perspective of whether or not their experience indicated the secondary mathematics curriculum had appropriately prepared the school leavers to handle the mathematics at their workplaces and generally for the labour market.

The significance of the research and the value of the data from each category should not be seen as separate elements, but rather as a collective. I argue that a lack of integration between any one of the sections of data collection would impact in some way with what happens within the other two categories. Hence the relationship should be seen as a collaborative symbiotic bond.

Despite what I had read in research literature on the subject of data collection in qualitative research, in the field I was to learn that formalities were replaced most of the times with the unconventional, but legally accepted and fit-for-purpose methods.

5.6.3 Gaining Access to Research Sites

Before collection of data could begin, my first task was to gain access to my designated research sites. Although there was a covering letter to facilitate my gaining access to my research sites (see Appendix C), the procedures I employed to gain access were different: some were informal, unconventional, on the spur of the moment and at times sporadic. **Tables 5.1-5.2** outline the manner in which I gained access to each of my research site.

Table 5.1: Access to my research sites

Sites	**How I gained access**
The Ministry of Education	During a social visit in conversation with the Director of Education, mention was made of my intention to use some of my colleagues as participants in my research. Her response to this information asked that I gave notice for the area that I would want them to focus on in the exercise.
Six secondary schools	Gaining access involved notifying the principals in a timely manner of my intention for the research exercise. My telephone was the instrument used in carrying out this act. Communication was at times directly with the Principal whilst for others it was via the schools' secretary.
The Verandah hotel	This took place during a lunch invitation at the hotel. Whilst my friend had been escorted to the receptionist's area, I stayed behind to engage the Manager in a conversation focusing on a visit for my research exercise. My request was granted and I was then directed to speak to his secretary to get an exact time and date.
President of the Antigua and Barbuda Union of Teachers (ABUT)	The Secretary of this organisation was given a message to ask the president to contact me via telephone.
Jumbie Bay	This occurred from a conversation I had with my Church's class leader. She gave me a phone number and suggested that I called the Manager of the Hotel, giving explanation for my visit. That telephone conversation with the Manager was how I gained access.
Allegro Pine Apple	It was suggested by one of my participants that I should speak to the Human Resource Manager. My conversation with the Human Resource Manager resulted in all arrangements for the visit being achieved.
Students from Conquistador's	When the invitation was extended by the head of mathematics department at conquistador to accompany her to this Fifth form classroom, I accepted.

Table 5.2: Continuation of data focusing on access to my research sites

Sites	**How I gained Access**
Jolly beach	This occurred from a face to face conversation with the Manager's secretary. Permission was granted for access.
Halcyon cove	I had an unscheduled appointment with the manager. During this conversation my intention was revealed. I was given her personal cell number to call later to ascertain the date and the arrangement for my visit.
Sandals International	During a conversation my sister, a friend and I were having whilst at the beach, I was asked if I wanted her to arrange some participants from Sandal's Hotel. My affirmation resulted with her making the necessary arrangements.
Custom's Division	This took place the second day upon my return to the island. The Controller of Custom's had exit his office through a side door on to the pavement where I was walking. I made known my intentions to use the division as one of my research sites. His response was: 'speak to my secretary, she will ensure that this could be done'.
The Markets	Access to Antigua and Barbuda's Vegetable Market, Meat Market, Fish Market and Craft Market required no permission.
Focus group	While on a mission at the Multipurpose Cultural Center, at the end of a grade six mathematics contest, I asked members of the judging panel to be participants to the research. They consented.
Marine Mechanic shop	By entering the shop and making my intentions known access was obtained.
Four former Directors of Education	Following the analysis of data from the present Director of Education, I had intuitively felt that more data were required from this source. I came up with the idea to use the former Directors. Phone calls to their homes gained immediate consent to be participants and for collection of data. For my fourth former Director it was from a coincidental meeting at the end of my data collection exercise in the vegetable market.

Time constraints on collection of data saw the exclusion of several participants. Included in the list were former Ministers of Government and now members of the opposition in the house of parliament; former civil servants and former Directors of Education for the period during the island's status as a colony.

A big omission from the data pool was the Stanford Business Empire. Once, the single largest private employer for the country, making a contribution of 25% to the country's GDP, the empire's demise was sudden. The United States Federal Law Agencies had begun Criminal proceedings against the owner allegedly for a *ponsey* operation. All properties were confiscated by the United States' Government.

5.6.4 Obstacles While Gaining Access

I needed to record some of the obstacles I encountered whilst trying to gain access (Opie, 2007). The first occurred when one of my hotel managers was not convinced that there was the need for me to come to the site to research the mathematics that was used by employees in their daily routine. It was a view that accorded that the normal addition, multiplication, subtraction and division with their classroom operations were the known mathematics operations in the workplace. However my persuasive argument caused an alternative view which allowed for my gaining access to the site.

I had a second incident at another hotel, where the gate keeper had requested that I waited a few days before expecting a response. Unknown to me, the gate keeper had made the necessary arrangements and was contacting me at an earlier date. Since I had been away from the island for a year and a half, the cell phone company had made my mobile phone inaccessible. Hence, attempts to contact me went unanswered. I never received a land line call. This resulted in a decrease in the number of participants from that site.

There were three cancellations of appointments before gaining access to speak to the gate keeper at another hotel. Administrative duties were cited as reasons; however my fourth attempt was successful. Yet in another hotel I had an obstacle where my entrance to the manager's office was almost immediate. Nevertheless attention to my business was not until two hours later. The manager was trying to have a computer problem resolved via telephone guidance with a colleague in another Caribbean country. These were the obstacles I encountered while trying to gain access.

5.7 Data Collection Procedures

In this section I discuss the data collection strategies including research design, participants, instruments and materials, procedure and analysis.

5.7.1 Research Design

The design was informed by Yin's (2009) definition of multiple case studies. My case studies were made up of sites to include Education policy makers' worksite, six secondary schools where the focus was on collection of data from heads of mathematics departments and principals; six hotels where employees from several sectors known to be areas in the hotel where school leavers generally sought employment; a private public utility plant; craft market, vegetable market, meat market and fish market; the administrative wing of the custom's division, residence of a former employee from a private sector enterprise and one commercial bank. The aim was to use the natural working environment of participants to help in my investigation of my research question. Similarly schools where class room mathematics was taught provided the working environment for some of my participants.

5.7.2 Instruments and Materials

Several instruments were employed in my collection of data. The main data collection tool for schools and the Ministry of Education headquarters was a *constructed conversation question sheet*. My *literature review* of mathematics in the workplace

(Chapter 3, p.52) was used as my foundation for suggestions in helping with construction of questions for each of the participants. However my main research question was always the main focus in devising questions. How and why the participants were part of my research was therefore very important.

Questions were therefore constructed to ascertain how and what roles were played by them in helping to ensure that students were appropriately prepared for the workplace whilst using the secondary mathematics curriculum in schools. Policy makers were asked to demonstrate how and what measures were taken into account to enable them to fulfil this role.

Generally in the workplaces, I adopted a *narrative* style for data collection. Here employees were asked to relate scenarios of a typical day's routine as they performed their roles in their workplaces. My aim in these circumstances was to depict what level of mathematics was involved in these activities and where in work was the mathematics embedded. It also was to assess whether or not school leavers entering directly into the workplaces were appropriately prepared to deal with the level of mathematics that formed part of their daily work. These narratives were related in a close-up face to face encounter.

Another tool employed in my data collection was that of *observation*. In the hotels it was important to witness live demonstrations of the actions and procedures involved in some of the activities of employees. These observations took place in actual workplace sites of the employees to include laundries, bars, kitchen, accounts departments, dining room, front desk, offices and customs department. Here I observed the participants at work in their natural environment and witnessed documents that were used in execution of their roles. At the worksite of the private utility plant, several sites were visited to demonstrate the change in the activities and therefore the change in the demands of the mathematics required to perform the jobs. These were guided tours.

A similar scenario was employed for the maintenance department where I was taken on tour to observe the activities involved at various sites and to depict the nature of the mathematics at work. During these sessions explanations would be offered as the steps involved in the completion of a task were initiated and carried out from initial phase to the end of the activity to give me an overall view of process and procedures. At each phase the activity that was taking place was outlined and I was then left to assess the mathematics that could be at work in each phase and further to assess if school leavers could competently perform these roles. Using the *observation tool* allowed me to gain an insight into mathematics at work in natural settings in workplaces.

Although anonymity was part of my ethical guidelines for this research, I also captured data using photography and videotaping in these sites. These pictures were also used as my measures to ensure credibility, trustworthiness and reliability and were incorporated into my data collection process. The pictures were to ensure that if called upon I could provide tangible proof to justify that I did observe what I claimed.

I also employed *structured conversation and structured interviews*. Other instruments employed were *documentations and archival records*. These were used to corroborate participants' claims especially where it pertained to statistical records of patterns of passes in examination of mathematics for school leavers. Other archival documents took the form of budget reports/documents demonstrating the amount of money spent in the education process; therefore ensuring that adequate resources were spent in the education sector to ensure that students were appropriately prepared for workplaces during their tenure of secondary education.

5.7.3 Procedure

During my data collection from the *Ministry of Education* headquarters, the tool used was *the constructed conversation question* sheet. In every case the data were collected from the participants in their workplaces/offices through face to face up-close encounters. The duration for each session was a minimum of thirty minutes with one exception where ten minutes were allotted to the Secondary Education officer. Nevertheless, participants were at liberty to go beyond this designated time frame.

The process during the collection of data was a format where I posed a question twice, allowed the participant to answer; I wrote the participant's responses verbatim in my note book before proceeding to a new question. At the end of some sessions the information collected was read back to the participants where there were doubts and confirmation was needed that the correct information had been recorded. Only in one case, the taped session was used directly to supply the correct data without the data having been written verbatim. Hence, information was gathered from the transcript. I found the process so time consuming and tedious that I vowed never to employ taping/recording and then transcribing text as a model for my data collection.

During data collection of participants in the *schools,* most of the data were collected in classrooms during and subsequent to a lesson. The location was either the staff room, where a participant was preparing for another class or in the office of the principal/deputy principal. When the principal's office was the room for writing collected data, the principal was away from the compound. In the case of the deputy principal, she requested to be present. In one school, the environment included both classroom and outdoors. This was for convenience as limited space for classroom duties was an issue. In some of the designated schedule for data collection I had to be flexible since these were environments in which participants were still performing ordinary class room duties.

At the hotels*,* the participants were asked to give a description of a typical working day in their roles. For the Chefs, the data were collected from a room chosen for its convenience. Health and safety control leading to the fear of food contamination ruled out the use of their kitchens in most places. However, at one site my photographer and I were allowed to observe the preparation of the meal for lunch for a fleeting moment. However it was long enough for us to take in the scenario while taking a few pictures.

At still another site, I was given a guided tour of the kitchen as the hotel was closed for maintenance purposes. Preparation of a meal was in progress, so the chief was questioned concerning the structure of the recipe. I had the opportunity to see the vessels used as cooking utensils and to assess the association of mathematics with the process. In addition to a description of the activities involved in their roles, the food and beverage managers were instrumental in giving a guided tour of the bar so that I could assess the mathematics embedded in the utensils employed in this environment and to detect whether I could identify black boxes (artefacts in which the mathematics operations were hidden) (Williams and Wake, 2007) in the workplace.

For assessment of mathematics associated with housekeeping departments, at two different research sites, *demonstrations and descriptions of activities* involved in their jobs took place in the context of their work environment. Here head of housekeeping departments demonstrated and outlined the process from arrival of garments to be washed to their conclusion as finished products ready to be used by guests.

It involved arrival of clothes; weighing of clothes; sorting of clothes according to texture; making of the decision as to the type of machine that should be used in conducting the washing or the ironing process; the right detergent to deploy for the job; the amount that would be adequate; the correct temperature for operation of the machines; the amount of water; how to eliminate wastage; process of cleaning of machines to avoid blockage; use of charts to help in calculation of measurements; the categorising of towels for guest rooms, whether single or double; indicated by pattern informing the folding of towels. The symmetry involved in organisation of furniture in the rooms. All these were activities employees were engaged in as part of their daily work.

Team work was also a noted feature in these operations. It was left, therefore, for me and sometimes the participants to help in identification of the mathematics in work. These were the activities of my data collection exercises from housekeeping departments. One head of housekeeping described her activities whilst speaking to me in the car park. The description indicated identical procedures in work as those I had witnessed in these two guided tours. In another hotel I learnt the same was the process from yet another head of housekeeping department. Here the data collected was more one of identification of the mathematics in her work.

The collection of data from the gardener also utilised *description of activities* involved in work. Additionally, I was then taken to some of the sites to witness some of what was described prior to visiting the areas. Similarly for front desk operators, description and actually observing them at work serving guests were the mode of data collection. The entertainment manager, the staff of the accounts department all gave an in depth account of the process involved in their work.

In the case of the resource managers who were also trainers of the newly employed, the content of the training was outlined and their perceptions of new employees' abilities were also discussed. In one hotel the session took place in the room where training of the newly employed actually took place. Many of the videotaping and photographs in the hotels took place during narratives where participants were outlining a typical day's work. The nature of the data collected from participants was discourses.

At the *Customs Departments*, data were collected from the participants in their workplace context. These were up-close contact with participants. In these sessions, listening, observing and writing the information were modes of data collection. The participants were seated at their desks whilst giving step by step descriptions and accounts of the activities and the procedures informing work. To validate and to give credibility to the conversational data, documents that were used by them whilst in the execution of their roles were produced as evidence. At the end of each narrative, I would then ask the participants to identify the mathematics in their work. This was done correctly every time.

At the private *Utility Power* house, descriptions of employees' roles were given at the various sites of the plant. These sites were over differing areas. Hence, my photographer and I were accorded a guided tour; sometimes it was walking; other times it was driven to the site because of the distances between sites. Here my ambition was to decipher the branch of mathematics that was in use at each site. The sites involved comprised osmosis plant: here issue of wastage was an important factor guiding operations; greenhouse nursery and a greenhouse; question of correct temperature, correct exposure to light; correct dosage of fertiliser; frequency at which plants were watered over any given period all formed part of daily routine.

There was also a recycling plant and several storage plants. Mathematics was involved in all these operations. On the way I saw employees engaged in building a wall: how many blocks were required to complete the wall was the question. The aggregate of sand, water and stones, what were the ratios involved? These were the mathematical answers being demanded. In the collection of data from workplaces I used to my advantage knowledge from the literature on workplace mathematics to identify the mathematics in work. From my reading of the journal article of Nicol (2007) I understood that it could have been difficult for me to identify the mathematics in work since the format and nature of workplace mathematics was quite different to that of classroom mathematics. This claim was further supported by Hoyles et. all (2010) in the book *Improving mathematics at work: the need for E*lsewhere in the literature the work of Evans (see Chapter 3), Williams and Wake (2007) and Bakker (2010) all support claim of the difference in format of formal mathematics taught in school and format of workplace mathematics (see Chapter 3 for more information). Unstructured-interviews, unstructured-conversation, narratives and observation were tools used to collect the data. Discourses, video recordings and photographs were the data collected. Some of the employees, especially those from the maintenance mechanic section were keen on identifying mathematics in their jobs and to assess whether the newly employed would have been able to cope with the mathematics in work.

In the *markets,* data were collected by employing tools of observation, unstructured conversations and unstructured-interviews, videotaping and taking photographs. Conversations or interviews were used to engage vendors in the processes involved in work to include unconventional means of weighing commodities. Observation was used to perceive the vendors' method of calculating sums of money for purchased goods and for returning correct change. I was also observing the choices made by consumers in choosing heaps of vegetables as part of their purchases: what was the reasoning informing the choices?

In the *craft market* I was asking participants to identify the mathematics in their work. One tailor agreed to take me through the process involved in the making of trousers while simultaneously identifying the mathematics in use at each phase of the procedure. The same mode was employed in my collection of data in the *fish market* and the *meat market*. In the *meat market*, an addition was the need for employees to acquire the skills for correct use of tools associated in this occupation.

Where data were collected at the *residence of participants*, the same mode as that employed at the Ministry of Education's headquarters was employed: asking questions, waiting for participants to answer and writing the answers. The telephone and email were also used in collection of data. Where the telephone was used, it was a structured interview; where the mode was email it was text. Where videotaping and photography were part of data collection, permission was first sought from the participant. Only after acquiring consent would the proceedings take place. Hence these were the processes and procedures I employed while collecting data.

5.8 The Quality of My Research

This section introduces trustworthiness and authenticity. The value of any research lies in the ability of the researcher to identify measures taken to ensure that data are not compromised and that there is a conscience central to operations and practices used in the execution of the research

5.8.1 Trustworthiness

Trustworthiness has four criteria. These are credibility, transferability, dependability, and conformability.

5.8.1.1 Credibility

> *This parallels internal validity. It addresses the question of whether there was a good match between researchers' observations and the theoretical ideas they developed. In qualitative research the significance of this stress on multiple accounts of social reality was especially evident in the trust worthiness criterion of credibility (Bryman, 2008, p. 376).*
>
> *It was the advanced view that if there could be several possible accounts of an aspect of social reality, it was the feasibility or credibility of the account that a researcher arrived at that [was] going to determine its acceptability to others (Bryman, 2008, p. 377).*

This was a criterion that I adopted during my collection of data where I employed this concept when I sought information for the same social phenomenon (my research question) from several participants. Additionally because I knew that 'the establishment of the credibility of findings [comprised] both ensuring that research was carried out according to the canons of good practice' (Bryman, 2008, p. 377) these components were features embedded in my research activities.

Simultaneously where the situation demanded returning to participants to corroborate whether my interpretations of the data I had collected from them were correct, this was invoked. Hence triangulation ('The process of using more than one method or one source of data in collecting data for the same research question' (Bryman, 2008, p. 379) and respondent validation ('process whereby a researcher provided participants with his/her interpretation of data collected from them and hence seeking their corroboration for the result') (Bryman, 2008, p. 379) were hallmarks of my research exercise. This action was taken to ensure that credibility was a component of my research.

In the view of Creswell (2009) in addressing issue of trustworthiness and credibility, there should be identification and discussion of one or more strategies available to check the accuracy of the findings. There were eight primary strategies (Bryman, 2008) organised from those most frequently used and easy to implement to those occasionally used and more difficult to implement. These can be categorised thus:

> *Triangulate different data sources of information by examining evidence from the sources and using it to build a coherent justification for themes. If themes are established based on converging several sources of data or perspectives from participants, then this process can be claimed as adding to the validity of the study (Creswell, 2009, pp. 191– 192).*

This was applied in my research with the data collected from the heads of mathematics department and secondary school teachers. It was also used in the workplace, when data were collected from different participants holding the same positions in the hotel industry. Thus for example, the same question was used to collect data from all the chefs, heads of house-keeping departments, and human resource participants. These data were then triangulated. This was to add to the validity of my data. Additionally, the theme was an added feature of the data ensuring that it was consensus of opinion that was used to arrive at suggestions from the research, and to avoid bias in interpretation of data.

> *Use [participant] checking to determine accuracy of the qualitative findings through taking the final report or specific descriptions or themes back to participants and determining whether these participants felt that they were accurate (Creswell, 2009, pp. 191– 192).*

Once I had collected data from my participants from the schools from principals, heads of mathematics department and at the Ministry of Education from the zone officers, I sought clarification from several of them to ascertain whether I had made the right interpretation from their specific data. This also was my approach with the entertainment participant from the hotels. My aim was to ensure that accuracy was a hallmark of my research.

Use rich, thick description to convey findings. When qualitative researchers provide detailed description of the setting, or provide many perspectives about a theme, the result become more realistic and richer. This procedure can add to the validity of the findings (Creswell, 2009, pp. 191– 192).

I did this when I reported procedure for collecting data from each participant of the heads of mathematics department in the schools. Some of it was deleted from this document fearing that word constraint would not allow for all this. However, in Chapter 6 and chapter 7 in my analysis of data from the education sites and workplaces, rich, thick descriptions were used to convey findings.

Clarify the bias the researcher brings to the study. This self – reflection creates an open and honest narrative that will resonate well with read (Creswell, 2009, pp.191– 192).

This was addressed in chapter 1, under the caption, *my story* (section 1.5) and *researcher's reflection* (section 1.7.4)

Present negative or discrepant information that runs counter to the themes. Because real life is composed of different perspectives that do not always coalesce, discussing contrary information adds to the credibility of an account. By presenting this contradictory evidence, the account becomes more realistic and hence valid (Creswell, 2009, pp. 191– 192).

I did not make this a major feature of my research, since my main focus was that of presenting the data accurately. However, I did question some of the statements found in the work of scholars in the field: one that stands out is the claim that qualitative research cannot be replicated. Another claim with which I take an alternative view is the one that argues that findings from one context cannot be used to solve problems in another setting. This would not hold true in the Caribbean, especially among the countries forming the Organisation of Eastern Caribbean States (OECS). Most of the problems in the education systems of Antigua and Barbuda are identical to those of other member states. That is why there is also a common approach to Educational matters among member states. Meetings of Ministers are held on a regular basis. I am confident that findings from my research could impact positively on policies in education in other Caribbean states.

Spend prolonged time in the field. In this way, the researcher develops an- in depth understanding of the phenomenon under study and can convey detail about the site and the people that lends credibility to the narrative account. The more experience that a researcher has with participants in their actual setting the more accurate or valid will be the findings (Creswell, 2009, pp. 191– 192).

Only three months are allotted for collection of data for this thesis. However since my research is being undertaken in the context of my work and the participants, especially those from the education department are known to me, since I am their supervisor or colleague, I have an in depth understanding of the problem of my research. I am, therefore, able to give details about the environment and the participants. In fact the problem is associated with my work. Additionally Antigua and Barbuda with a population of a mere 80,000 people makes it possible for all of these participants and the environments to be familiar territory to me. Hence I am able to get even more intricate data that a complete stranger would not be afforded. Hence I am confident with the integrity of the data I have collected.

Use peer debriefing to enhance the accuracy of the account. This strategy – involving an interpretation beyond the researcher and invested in another person – adds validity to an account (Creswell, 2009, pp. 191– 192).

I am privileged that as a research student at the University of Nottingham to have the services of supervisors who are diligent in their work and encourage accuracy in reporting. In fact some of their statements are now axioms while writing this report. Two of which are:

Precision in thought, precision in reasoning (Fisher).

There needs to be analysis and not opinions. One's opinions need to be based on evidence. And for research based need to be systematically examined (Gates).

These supervisors are extremely objective in their approach to their work and keep one focused to the work at hand. No opinions, always asking: 'where is the evidence' (Convery). Additionally, I do use my fellow researchers from all the continents of the world for my peer debriefing. It is a practice encouraged here at this University. Sessions are held by a faculty member to ensure that this practice is seen as part of the tenets of the researcher. Hence my work has benefited from this practice.

> *Use an external auditor to review the entire project. This auditor should not be familiar with the researcher or the project and can provide an objective assessment of the research. The procedure of having an independent investigator look over many aspects of the project example, accuracy of transcription, the relationship between the research questions and the data, the level of data analysis from the raw data through interpretation enhances the overall validity of qualitative study (Creswell 2009, pp. 191– 192).*

I am using an external auditor to reviewing my entire report. This is a complete stranger but a professor (New Zealand) who has examined work of this nature. In fact he has been contracted by the government of Grenada to assist them in establishing their indigenous University. His comments are as thorough and objective as those of my supervisors.

The processes and procedures adapted by me in my research exercise and now writing up of the report were predicated on most of these eight primary strategies advanced by Creswell (2009).

5.8.1.2 Transferability

This criterion 'parallels external validity' (Bryman, 2008, p. 377). This referred to 'the degree to which findings could be generalized across social settings' (Creswell, 2009, pp. 191-192). Although Le Compte and Goetz (1982) perceived 'transferability as representative of a problem for qualitative researchers, because of their tendency to employ case studies and small samples' (Creswell, 2009, pp. 191-192), I took an alternative view and argued that there were exceptions to this view. As educators in the Caribbean, despite our different territorial and geographical terrains and therefore social settings, we do share common objects and goals in the governance of our countries.

In the field of education this is one such case. As it pertains to my research, we (Antiguans and Barbudans) share the secondary mathematics curriculum in preparation of school leavers for the labour market with other islands in the Diaspora: from Guyana in the south right up to Jamaica in the north, embracing Belize, Honduras and Guatemala. We also share the same assessment processes employed by the Caribbean Examination Council's examination board.

Additionally, Ministers of Education from the different islands function as a single collective subject because of the realization, that generally, the education problems are identical among member states in the union of the Organisation of Eastern Caribbean States (OECS) and countries of The Caribbean Common Market (CARICOM) territories. Hence, I would argue that results from my research could address problems and needed changes in any of the other Caribbean Islands. A similar argument could be advanced for feasibility of the transferability criterion concerning my findings to other countries using the Caribbean Secondary Mathematics examination curriculum as it relates to use of suggestions from the findings of my research; albeit that they are from different social settings.

During my tenure as an assistant examiner for the Caribbean Examination Council mathematics marking panel, in the annual Caribbean Examination Council's school leaving exercise during the period 1997-2000, the problems discussed around the marking venue resonated similarly with known problems in my country. In fact the consensus was that the problems in each of the countries are the same for the majority of cases. This made it convenient for Caribbean examination council officials to convene seminars with teachers from the different countries using the syllabus to address such issues. I have been present at these forums and know that the problems were generally the same.

Hence common suggestions to address issues in our various countries were the result of outcomes from these sessions. I argue that where the object for the research was identical to the objects in other social settings, despite employing case studies or working with small samples it should be possible to employ this transferability criterion. Therefore I support the views of Lincoln and Guba (1985, p. 136) that 'whether findings hold in some other context, or even in the same context at some other time, is an empirical issue'.

Further, I support the suggestion of Geertz (1973) for 'calls to produce thick description – that was, rich accounts of the details of a culture' (Bryman, 2008, p. 378). Indeed Lincoln and Guba's (1994) argument that 'a thick description provided others with what they referred to as a data base for making judgements about the possible transferability of findings to other milieu' (ibid) was one that resonated with my stance on this issue. Hence it is my expectation that there will be transferability of suggestions from my research across social settings.

5.8.1.3 Dependability

This criterion advanced as 'a parallel to reliability in quantitative research, Lincoln and Guba (1985) proposed the idea of dependability and argued that in order to establish the merit of research in terms of this criterion of trustworthiness, researchers should adopt an 'auditing' approach' (Bryman, 2008, p 378). Implicitly the auditing approach was a feature of this research since steps were taken to ensure that 'complete records were kept at all phases of my research process' (Bryman, 2008, p. 378). I got a special suitcase to act as house for all documents and written material I used at any juncture of my data collection. I also used my computer for another alternative for a database, saving the typed material of transcribed data in my documents in the words programme. So that today I can open the suitcase or use my words programme to access any data needed from my research. This was the action that facilitated the construction of my data base.

Additionally photographs and videotaping were used to ensure the component of dependability was a feature of this research. Although I cannot say with any alacrity that if replicated the same results would be obtained by another researcher because of differences in conditions and participants' views, which cannot be frozen in time or conditions reconstructed in the qualitative paradigm, I am confident that my techniques could be used to provide creditable suggestions for research problems.

5.8.1.4 Conformability

According to Bryman (2008, p. 379) 'conformability was concerned with ensuring that, while recognizing that complete objectivity was impossible in social research, the researcher can be shown to have acted in good faith' *.* That is, it should be apparent that I had not consciously allowed personal values or theoretical inclinations to govern my conduct in execution of data collection exercise or my interpretation of findings from my research. While Lincoln and Guba (1985) proposed that establishing conformability should be one of the objectives of auditors, my contrary view was that on the question of values this should not be transferred and that it was a role that rested squarely within the domain of the researcher. The auditors could perform other roles; but my argument supports the view of ensuring that this task remains with the researcher. I argue it is a task that is wrapped up with the methodological paradigm of the researcher. Chapter 1, section 1.5 outlines the provision I made to ensure that my personal values, consciously do not impact negatively the result of my research through my data collection exercise or during any of the various stages of my research process.

Hence, I argue that the four criteria for trustworthiness informing qualitative research are features of my research.

5.8.2 Authenticity

Lincoln and Guba (1985) saw the necessity for further concretisation of the second alternative view advanced to assess the qualitative research. This was achieved by assigning several criteria to the authenticity paradigm to address the issue of quality in qualitative research. These were the criteria:

5.8.2.1 Fairness

> *Does the research fairly represent different viewpoints among members of the social setting (Bryman, 2008, p. 379)?*

During my data collection exercise all participants were accorded as long as was necessary to make their contributions to the research question. All views were contended. There were no omissions on the grounds of differences in opinion from that of mine (the researcher). Hence I argue that *fairness* was a component of my research.

5.8.2.2 Ontological Authenticity

> *Does the research help my arrival at a better understanding of my social milieu (Bryman, 2008, p.379)?*

This has been the hallmark of my research. I was not only helped to arrive at a better understanding of my social milieu but was also helped with gaining a better understanding of my world view in my quest for construction of knowledge. This has further enhanced my perception for what should be the attributes employed in trying to acquire an education. For the first time in my life I can discuss the question of what it means to get an education in contrast to what it means to get a qualification. Hence my understanding of this epistemological paradigm and therefore my ontological paradigm did play a major role in helping me to arrive at a better understanding of my social milieu.

5.8.2.3 Educative Authenticity

> *Does the research help me to appreciate better the perspectives of other members of their social setting (Bryman, 2008, p.379)?*

This research is being performed to help in my uncovering areas in my practice in need of change. It is further a mission desired to help in acquisition of relevant suggestions that could help policy makers as they prepare to chart the way forward in designing a mathematics education programme that could prepare students for the labour market of the twenty first century and beyond. Yet another reason is that of acquiring suggestions and ideas to help in changing the way in which mathematics is taught and is learned in our schools.

Hence support for teachers is a prime goal. The challenges faced by policy makers, classroom teachers and the expectations of employers for the newly employed is clearer by my having performed this research. It was a delight to visit the various worksites and to see how people functioned. The classrooms and views of teachers and students were experiences that I could never forget. This is also evident in the case of the policy makers. Thus, it is my view that this research has helped in my appreciation for the perspectives of other members of their social setting. I hope to demonstrate this in my analysis and presentation of findings from the data.

5.8.2.4 Catalytic Authenticity

> *Has the research acted as an impetus to [member] to engage in action to change her circumstance (Bryman, 2008, p. 379)?*

This research could be the catalyst that provides the attributes I need to revolutionize teaching and learning of mathematics in Antigua and Barbuda. The exercise has proven and has shown me that research component should be an integral factor in the operations of every education system. Empirical data are necessary in the enacting of changes in any productive, efficient and progressive educational system.

5.8.2.5 Tactical Authenticity

> *Has the research empowered members to take the steps necessary for engaging in action (Bryman, 2008, p.380)?*

This research has empowered me to take the necessary steps for engaging in action. Before one could embark on purposive action, relevant information, fit for purpose and diagnosis of structural problems needed to be signposted. My purpose in pursuing this research at this stage of my career is that of better preparing myself with the appropriate knowledge that could contribute to the desired changes in my practice, to improve the mathematics education programme. Additionally, my purpose is to ensure that policy makers are provided with significant and with relevant information that could help in policy making exercises.

Hence from my membership with several professional associations, as participant and observer at conferences: British Society for Research in Literature for Mathematics (BSRLM), International Psychology Group of Mathematics Educators, (IPGME), British Congress for Mathematics Educators (BCME), Commonwealth Policy Studies Unit, (CPSU), exposure afforded from the Commonwealth Association of Universities via conferences and seminars; and all the seminars and conferences from my own University of Nottingham (UoN) and its graduate school while preparing to embark on this research exercise, I have accumulated sufficient knowledge which should prepare me for future roles in mathematics education and for informing the education process in general. This research has truly empowered me to take the necessary steps for engaging in action of leading the mathematics education programme forward.

5.9 Data Analysis Procedures

This section introduces instruments used for analysis of data and the rationale for the choice. Miller (1992), Merrian (1988) and Marshall and Rossman (1989) each contend that data collection and data analysis must be a simultaneous process in qualitative research. That was why in my research there were two analysis processes: one immediately upon collection of the daily participants' data during the field work and later for the presentation of the findings in a written report. The former analysis allowed for my revisiting participants whenever it was warranted due to my interpretation of the collected data. In some cases this resulted in my initiating changes to the original schedule, adding new participants or excluding some participants.

Schatzman and Strauss (1973) claimed that 'qualitative data analysis primarily entailed classifying things, persons and event and the properties which characterized them' (cited in Creswell, 2009, pp. 198-199). During my second data analysis process I coded my data using as many categories as I felt were needed (Griffiths, 1998) until I felt I reached saturation. I identified and described patterns and themes from the perspective of the participants and then attempted to understand and explain these patterns and themes (Agar, 1980). The data were organised categorically and where the same questions were directed at more than one participant, the answers were written side by side to extract similarities or differences in received responses. My aim was to draw out the main themes. Lists of major signposted ideas were recorded. Taped interview and the participants' oral responses were recorded in my notebook verbatim.

My data analysis was aided by the Engeström's (2001), Cultural Historical Activity Theory, second generation model in helping to unmask contradictions in the discourses of participants. This identified areas for change in my practice while additionally informing mathematics education in general in the state of Antigua and Barbuda. I used Engeström's discursive table to assist in categorization of the discourses in identifying main themes. Simple arithmetical and statistical operations were used to elucidate further warranted explanations. Additionally workplace literature using the work of scholars in the field, assisted in my identification of the nature of mathematics in use in workplaces of Antigua and Barbuda. Information was used to help in the analysis of drawing the contrast between mathematics in use during the colonial era in contrast to mathematics required in the job market of the 21st century. The analysis is the content of Chapter 8.

Hence the tools used for the analysis of the data comprised:

(i) The triangular configuration of the Engeström (2001) CHAT second generation model.

(ii) Five principles upon which the activity theory is founded.

(iii) Discursive Tables with elements to help in identification and categorization of contradictions in the responses of participants

(iv) Literature review (Chapter 3) where the focus is the nature of workplace mathematics.

5.10 Summary

In this chapter I present the methodology of my research. Additionally, I address ontological and epistemological paradigm in conjunction with my role as the researcher. The procedure for analysis and the sources of evidence involved are part of the presentation. The next chapter presents the first of three chapters reporting the analysis of the data.

Chapter 6 - Analysis of Teachers’ Activity System

6.1 Overview

In this chapter, I present the analysis of data to one subsidiary question: *Is the mathematics taught in the secondary schools of Antigua and Barbuda by mathematics teachers appropriately preparing school leavers to handle the mathematics in the job market?*

6.2 Introduction

Although the main research question is: *given the increase in technological tools in the labour market of Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the workplace?* I found it purposeful to divide the analysis into three distinct components: two activity systems founded upon the Engeström (2001) second generation cultural historical activity theory (CHAT) triangular model, namely the secondary schools’ activity system and the employers’ activity system; prior to the analysis focusing on the main research question.

6.3 Procedure for Analysis

The analysis of the data is governed by three questions: the main research question and two emerging subsidiary questions. I present the analysis for the two emerging subsidiary questions in Chapters 6 and 7 respectively. Finally in Chapter 8, I present the analysis to the main research question.

First, I present the data and the analysis of the participants’ responses associated with this specific subsidiary question. The participants were drawn from: secondary school mathematics teachers, zone officers (4), Director of Education, Permanent Secretary, students, Mathematics Officer Secondary schools, Mathematics Officer Primary schools, Curriculum Development Officer, Heads of Mathematics Departments in Secondary Schools, one Focus Group, the Testing and Evaluation Officer and the Minister of Education. The collection of data from a variety of participants was in keeping with the multi-voicedness principle demanded as one criterion when using activity theory as my theoretical framework and as my analytical tool.

Although data were collected from many sources, in the end only the data from those participants, which were specifically related to the research questions, were part of the analysis of data. This elimination of irrelevant data conformed to the principle of data reduction. Hence, the data for analysis from the school's activity system came from the following participants:

- Heads of Mathematics Departments from Secondary Schools
- Secondary school principals
- Mathematics Officer secondary schools
- Present Fifth, and former Student

Positioning of participants in the activity system is directly related to their roles in the system. Their positions also signal the part each played in offering support to the work performed by the *Subject* (teachers) of the activity system.

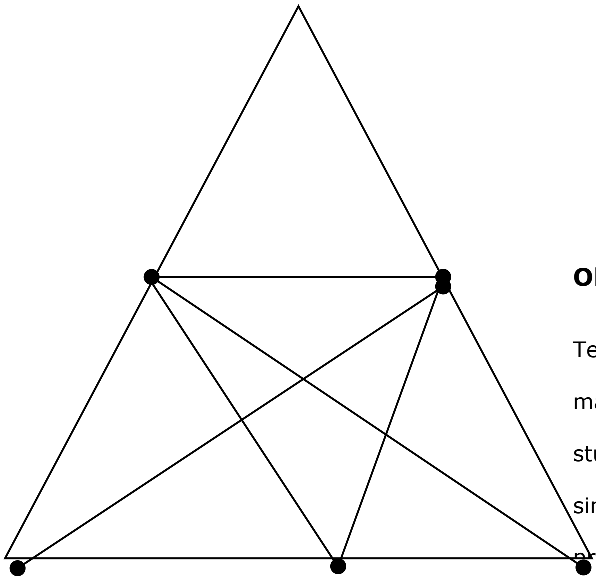
6.4 The Schools' Activity System

In this section I introduce the schools' mathematics activity system, associated with the subsidiary question informing this chapter. The triangular configuration depicts positions assigned to participants (see figure 6.1). A rationale is offered for each designated position.

Figure 6 Activity System for mathematics programme in Secondary Schools

Tools

- Curriculum
- Maths text books
- Past examination papers
- Different teaching strategies



Subjects

Heads of mathematics Departments/

Object:

Teach mathematics to students and simultaneously prepare them

Transformation

Process

Goal:

Students learn mathematics and gain a passing grade in CSEC Mathematics Examination

Rules:

- Civil service Act 2004
- Education Act 2008
- Union Contract

Community:

- Minister of Education
  Director of Education
- Curriculum Development Officer
- Testing and Evaluation Officer
- Parents

Division of labour:

- Principals
- Mathematics officer secondary school
- Former Students/employees

Realizing that the use of tools, object and rules governing operation of this activity system are directly influenced and controlled by the human component of the system, in examining elements of this activity system, only rationale for the choice of participants are addressed. In fact, the choice of participants is governed by the research question.

6.4.1 Rationale for Choice of Participants' Subject

Training of students in mathematical knowledge in classrooms is the chief task of mathematics teachers in the education system. Hence this research question is directly related to this task. Thus implicitly it is the role of teachers in the mathematics classrooms across Antigua and Barbuda that is under investigation. The investigation analyses whether in their role as trainers of students for the work force, the training was effective. The decision to use conversations from the heads of mathematics departments was to signal the collectiveness or the multi-voiced nature of the data. Data collected form heads of mathematics departments represent the views of all members in the respective department (see data below for function of heads of mathematics departments).

Division of Labour

The research question is bringing into focus a myopic view of the activities engaging students' preparation for the world of work. Therefore, of the multiplicity of activity systems informing the mathematics program in the secondary schools of Antigua and Barbuda, only the data from participants directly affiliated to classroom work of teachers are featured in this analysis. Hence data from the mathematics officer for secondary schools and the secondary school principals form part of the analysis.

Secondary school principals are managers of the school plant. All activities informing the timetable in secondary schools should be monitored by them to ensure that teachers' activities in classroom conform to the policies from the Ministry of Education. Thus supervision of classroom lessons is a part of their portfolio. Hence based on this classroom observation and information that would have been received from the head of mathematics department, first-hand knowledge of school's mathematics programme qualifies the secondary principals to address the research question.

Acting on behalf of the Ministry of Education, it is the role of the Mathematics officer to ensure that teachers are teaching mathematics knowledge from the prescribed mathematics curriculum. Therefore, this involves spending time in the classroom observing teachers delivering mathematics lessons. Hence insight into appropriate preparation of students could be acquired. Additionally, capability of teachers to transfer the mathematics knowledge to students allowing for appropriate preparation of students to handle mathematics in workplaces could have been depicted. The Mathematics Officer is also the one conducting workshops and advocating additional training for teachers to ensure that they are adequately prepared to comprehend and to teach topics in the mathematics syllabus. Hence the significance of this data to my analysis of this research question.

6.4.2 Rationale for Omission of Data from Community

While members of the *Community* do share the object (ive) of the teachers and principals and some of these members are indeed the bosses of the teachers, principals and mathematics officer, information collected by them based on the research question would be second hand information. Their role is primarily one of supplying the necessary resources to ensure the success of teachers' classroom activities and formulating policies to govern the government's mathematics programme in secondary schools.

Additionally, while the curriculum officer is responsible for the construction of curriculum used in primary schools of Antigua and Barbuda, the mathematics curriculum informing classes are instruments provided by the Caribbean Examination Body, an external entity mandated to act as Examining body for secondary education in Antigua and Barbuda. Hence the local curriculum officer plays no role in construction of content for the secondary mathematics programme. Similarly because all school leaving examinations performed by Antigua and Barbuda Secondary School Students are graded by the Caribbean Examination Council (CXC) the Testing and Evaluation Officer plays no role in assessment of students in secondary schools.

In the cases of: Director of Education, Permanent Secretary and Minister of Education, only examination results and reports submitted by officers and principals were the yardstick for providing suggestions to this research question. Hence my decision to eliminate their data from analysis to the research question for this chapter.

The tools, rules, object (ive) and outcome are all integral tenets of the mathematics teachers' ability to perform an efficient role (tool, appropriate for the task?), to operate in a stable and safe environment (rules) and to achieve the mandate of the Ministry of Education (outcome). Thus I am suggesting that these elements of this activity system could form part of the data from the participants associated with this research question for this Chapter.

Each of the sites from which data was collected constituted one of my case studies. Hence a variety of different sites provided the multiple-case study profile. Each school's location was different. So too were the rules, norms, culture, class sizes and socio-economic background of students. Additionally the worksite for the Mathematics Officer was different from those of the other participants.

6.4.3 Timetable for Data Collection

Table 6.1: First two days of data collection: venue - Ministry of Education

Dates	Time	Venue	Participants	Methodology	Tools
16/04/09	10:00-10:30am 11:00-11:30am 1:00-1:30pm	MOE MOE MOE	Moses Testing and Evaluation Officer Permanent Secretary	Structured Conversation Structured Conversation Structured Conversation	Prepared questions; tape recorder; camera; notebook; pen; photographer.
17/04/09	3:00-3:40pm 1:00-1:15pm	MOE MOE	Director of Education Senior Education Officer for Secondary Schools	Structured Conversation Formal Conversation	Prepared questions; tape recorder; camera; notebook; pen; photographer

Table 6.2: Time table of the second week for data collection

Dates	Time	Venue	Participants	Methodology	Tools
20/04/09	11:00am - 11:30am 11:35am - 12:10pm	MOE MOE	Linda Anne	Structured Conversation Structured Conversation	Prepared questions; notebook; camera; photographer
21/04/09	3:13-3:50pm 3:55 - 4:15 pm	MOE MOE	Christine Tyler	Structured Conversation Structured Conversation	Prepared questions; notebook; camera; photographer
24/04/09	9:30-10:15 am. 10:20-10:30am.	MOE MOE	Minister of Education Permanent Secretary	Formal Conversation Formal Conversation	Notebook; pen; photographer Notebook; pen.

	10:35-10:50	MOE	Testing and Evaluation Officer	Formal Conversation	Notebook and pen
28/04/09	11:00-11:30am. 11:35am. -12:00 noon	Conquistadores Secondary's Staffroom Conquistadores Secondary's classroom	Harris Fifth Formers of Conquistadores' (SP)	Formal Conversation Unstructured Interview	Notebook; pen; camera. Notebook; pen; camera
29/04/09	10:30-11:30am. 11:35-11:50am.	Macedonia Secondary's Deputy' principal's office. Macedonia Secondary's Deputy principal's office	Francis Fifth Formers at Macedonia (SJ)	Structured Interview Unstructured Interview.	Prepared questions; notebook; pen; camera; tape recorder; photographer. Pen; notebook; camera; photographer

Table 6.3: Time table governing activities of the third week

Dates	Time	Venue	Participants	Methodology	Tools
30/04/09	09:15am-10:00am	MOE	Athena	Structured Interview	Tape recorder; memory stick; laptop; pen notebook; camera; watch and photographer.
	10:0am-10:30am	MOE	Accreditation Office	Unstructured Interview.	Notebook; pen; camera; photographer and watch.
	11:00am – 11:45am	MOE	Director of Curriculum and Other Education matters	Structured Interview.	Notebook; prepared questions; camera; watch and photographer.
01/05/09	10:15am-10:50am	Phillip the Second Secondary's fifth form classroom	King	Structured and unstructured Conversation.	Prepared questions; spontaneous questions; camera; photographer; watch; notebook and pen.
	11:10am-11:45am	Alexander the Great Secondary's classroom and outdoor study area.	Henry	Structured Conversation.	Prepared questions; tape recorder; notebook; pen; camera; watch and photographer.
	11:50am-12:20pm	Principal's office.	Sir	Structured Interview.	Notebook; pen; structured questions; camera; watch and photographer.

Table 6.4: Itinerary governing data collection in May 2009

Dates	Time	Venue	Participants	Methodology	Tools
04/05/09	11:00am-11:10am	Site of 2009 Trade union Congress' labour day RallyT.N.Kirnon School's Playing Field	Minister of Labour and Cooperatives	Interview	Notebook; camera; watch; pen and photographer.
05/05/09	11:10am-12:35pm	Principal's office at Aristotle Secondary school.	Spencer Madam	Structured Conversation Unstructured Conversation	Notebook; prepared questions; unprepared questions; watch; pen and photographer.
08/05/09	11:00am 11:45am	Principal's office at Thessaloniki Secondary	James	Structured Interview	Notebook; prepared questions; pen; watch; camera and photographer.
11/05/09	11:00am 11:35am	General's Residence	General	Structured Interview	Pen; note book; prepared questions; watch; camera and photographer.
12/05/09	4:00pm 4:20pm 6:00pm 7:15pm	Researcher's residence Researcher's residence	Cheryl Luther	Telephone Interview Telephone Interview	Prepared questions; notebook; pen; telephone and watch. Prepared questions; notebook; watch; pen and telephone.
16/05/09	10:30am-11:00am	Public Vegetable Market	Major	Formal Conversation	Pen; envelop and camera.

Table 6.5: Itinerary of data collection for June and for July 2009

Dates	Times	Venue	Participants	Methodology	Tools
11/06/09	1:00pm-1:30pm	Pineapple Hotel's Maintenance Office.	Cher	Formal Conversation	Pen; notebook; watch and camera.
15/06/09	12:00am-12:25pm	Multi-Purpose Cultural Centre	Innovators	Focus Group and Unstructured Interview	Pen; notebook; camera; watch and prepared questions
02/07/09	9:45am-10:15am	MOE	Minister Of Education	Formal Conversation	Pen; notebook; prepared questions and watch.
14/07/09	11:00am-11:30am	Woods Shopping Mall.	President of Antigua and Barbuda Union of Teachers (Lyn)	Structured interview.	Pen; notebook; watch; camera and photographer
15/07/09	12:00am-12:15pm	Parham Fishing Complex	Laurie	Interview	Pen; notebook; camera and watch.

6.5 Analysis of Data Governing Subsidiary Question 1

In this section I use the data from the aforementioned participants to provide suggestion for the first subsidiary research question: *is the mathematics taught in the secondary schools of Antigua and Barbuda by mathematics teachers appropriately preparing school leavers to handle the mathematics in the job market?*

Two approaches were employed in executing the analysis of the data. In the first (present analysis), I employ a typical approach to the analysis of contradictions relying on Engeström (2001) second generation model of cultural historical activity theory (chat). In the second approach (Chapter 7) I use a format where information from my literature review focussing on the different types of workplace mathematics to be found globally helped in my identification of the various branches of mathematics informing activities in the workplaces of Antigua and Barbuda, where mathematics was a part of the routine of the job. For the remainder of this chapter, I present the analysis using the first approach.

6.5.1 Analysis of the Teachers' Activity System

In this first approach to the analysis, I begin by way of a description of the elements: subjects, tools, object, division of labour, community, rules and outcome (see Chapter 4, figure 4). My multiple case studies comprise each of the secondary schools that are used in this research. My *subject* is the mathematics teachers represented as a collective by the heads of each of the mathematics departments of the schools. The *object* is teaching mathematics to students; the desired *outcome* is that students gain a passing grade in the annual end of school CSEC Mathematics Examinations. Simultaneously students should be appropriately prepared to handle the mathematics in the labour market. The *tool* is the secondary school mathematics curriculum, with teachers using relevant, pedagogic methods and or technology, when delivering content of the curriculum to students. The division of labour includes the secondary school principals and the mathematics officer (Ag) for secondary schools. The *community* includes other mathematics teachers, parents, NGOs, policy makers and the Minister of Education. The rules are governed by the Civil Service Regulations 2000, school rules and prescriptive rules from the policy makers of The Ministry of Education (Education Act 2008).

The participants whose data form part of the analysis are directly associated with the activity of teaching students, with the mandate to appropriately prepare them to handle the mathematics at their workplaces, subsequent to graduation from secondary schools. Hence, while the analysis incorporates the triangular configuration, the data for this analysis were sourced from:

- Heads of mathematics departments
- Principals
- Mathematics Officer Secondary schools
- Students (present and former)

While members of the *community* are involved in the provision of resources to ensure successful preparation of students but are not directly involved in the activity of teaching, their data did not form part of this analysis. This analysis comprises four phases. In phase one, I identify the exact text from each category of participants that addresses the first subsidiary research question. In Phase two, I analyse each data with a view of identifying the common theme for each category and also collectively. In phase three, I analyse other data from the participants which are not associated with the first subsidiary research question but are part of the teachers' activity system. This is to ascertain what factors are responsible for the preparation or non-preparation of students for the job market. Finally in phase four, I assess data to assist my identification of areas in the system in need of change. I use the Engeström (2010) discursive table to identify the contradictions in the responses from the participants associated with this research. Based on findings, conclusions and suggestions will be drawn. In the next section I present the data for each participant addressing the research question.

6.5.2 Analysis: Phase One

In this section I use data from the heads of mathematics departments, secondary school principals, mathematics officer for secondary schools and students to provide suggestions to this first subsidiary question. Since the heads of mathematics departments are the *subjects of the activity system,* their activity system is the one informing this analysis. The principals and the mathematics officer as members of the *division of labour* in this system and being directly involved with the activity of assisting the heads of mathematics departments with the execution of their task of teaching mathematics to students and simultaneously their appropriate development for the workplace will also form part of this analysis.

The students involved in this exercise are also given a voice. Since the students would not have been in a position to say with any degree of accuracy whether or not they had been appropriately prepared to handle the mathematics in the workplace, their contribution is being sought to allow readers to draw their own conclusion as to students' appropriate preparation for the workplace and their ability to handle mathematics in the job market. Data collected from each of the elements for the activity system in this section are examined individually and subsequently as a collective. In the next section I examine data from the *collective subject*: heads of mathematics departments, as they seek to provide suggestions to the research question.

Using Data from Heads of Mathematics Departments

In this section I use the responses from each of the six case studies to provide suggestions to the first subsidiary research question. It therefore allows for my applying a multi-voiced technique to arrive at suggestions which are free from prejudice or bias.

Additionally pseudonyms have been used as names for each head of mathematics department to ensure anonymity of participants. Thus, the responses address the first part of the question, where the *self* is the focus. Hence when participants were asked *whether school leavers were appropriately prepared for the job market, these were the responses*:

Ilma: *No, it is not relevant to the students' experience; also not a lot of it is relevant to everyday life. Because in creating a syllabus, there is need for additional information to enable this to be realized. And although the Basic Syllabus was constructed for this purpose, the method and marketing strategies were grossly inadequate.*

Whitfield: *No the curriculum topics taught in school do not allow this to be conveyed to students. Students associate the concepts taught with problems asked to solve items on classroom administered test or the annual CSEC Examination. There is no linkage with any other aspect of their real world experience.*

Gertrude: *Relationship between the content of the mathematics curriculum and the students' way of life……… they live it, but still the mathematics vocabulary is not one with which they are acquainted. There is the need to introduce some mathematics vocabulary which is relevant to the various topics to be covered.*

***Cardinal**:* *In our school system we practice using of our human resource for the wrong goals. Curriculum in use in school should have been more practical based. It should have had a component prerequisite where discussions of topics must be a part of each topic. So for example, in teaching quadratic equations there could be a discussion about missiles and relate it to work before getting into the algorithms of the topic. The syllabus should be so constructed as to guide the teachers.*

Ulric: *The emphasis in the classroom makes learning of mathematics an examination based subject. The practical aspect of mathematics is not stressed and the syllabus does not have a practical component. Students see mathematics as a subject whose passing grade would ensure that they get a good job in the future. So in this perspective they see the relationship between mathematics and career as one for matriculation for a good job or for entrance into tertiary institutions.*

In my view, the above data could suggest that when teachers present the various topics on the CSEC mathematics curriculum using the formal language of the text the students may not have necessarily grasped the taught concepts and were therefore unable to relate them to the world of work. Hence this could have probably impacted negatively the students' preparation for the workplace.

Appropriate Preparation for Different Careers

In this section I present the data from the head of mathematics departments in the secondary schools addressing the second part of this question: whether the mathematics taught using this curriculum allowed for the appropriate preparation of students to pursue the different career trajectories in the labour market. I employ the anonymity rule demonstrated by my use of pseudonyms in naming the participants. This is what the participants had to say (see subsection 6.5.3, question 7, p.):

Ilma: *Yes, some topics would be able to lend themselves: it all depends on the job. For example, the topic of bearings would be aligned with a career for a pilot; while consumer arithmetic would feature in the daily calculations*.

Whitfield: *Yes, there is measurement for the carpenters, consumer arithmetic for the entrepreneur, and statistics for the statisticians*.

Gertrude: *Yes, although some students would not recognize that trigonometry would be associated with pilots and surveyors. But consumer arithmetic is used in everyday mathematics. Another example is for carpenters, using measurement, geometrical shapes, geometrical lines, angles and Pythagoras' Theorem.*

Cardinal: *The curriculum topics do address the different trajectories of students. But since the main concentration of teachers is to finish a syllabus in preparing the students to write an examination, I am not sure, whether students see the connection between the mathematics being taught in school and their future career.*

Ulric: *Not all the time. But sometimes students would synchronize content to fit their career goals. Different trajectories are not fully covered by the CXC Curriculum. There is a bias towards academicism.*

Michael: *The content addresses the different trajectories of students.*

My Interpretation of the Data

Emerging from the responses is the suggestion that the content of the CSEC Mathematics Curriculum does allow for the users to address the topic of preparation of students for the mathematics that would be required in the different choices for a career. Indeed the fact that some students had been known to take the initiative to 'synchronize topics to fit their chosen careers' (Ulric), provided credence to the claim of curriculum's content being able to prepare students for the workplace.

Thus I could argue that where this was not the case in the activity system of teachers, it could suggest a probable lack in ability of teachers to integrate formal classroom mathematics lessons with the world of work. Teachers are working in a society where there is hardly any communication between the world of work and schools: more specifically between employers and teachers. Hence one could not reasonably expect teachers to readily make the association between school and the world of work.

Finally, I examine appropriate preparation of students to handle the mathematics at their workplaces.

Ability of Newly Employed to Handle Mathematics in the Workplace

In this section I provide responses from the heads of mathematics departments addressing the question of the students seeking employment in the labour market ability directly upon graduation from secondary school to handle the mathematics associated with their present jobs. Below are the responses:

Ilma: *I believe that because they are at workplaces where there is on-the-job training, yes, they probably would be able to handle the mathematics at their workplace.*

Whitfield: *Students have a fear for the subject. Hence I do not know if they would be able to handle the mathematics in their jobs……..but yes, on-the-job training could make this possible.*

Gertrude: *Yes, on-the-job training would allow students to master the mathematics for the workplace: especially if it involves a practical perspective.*

Cardinal: *The mathematics curriculum in secondary schools is built to facilitate the interest of the Caribbean Examination Council (CXC). Users are not free to put whatever take they deem necessary: because one has to be guided by examination requirement for CXC. It is not an open ended situation. It is guided and closed. We have to do mathematics that is not in the interest of national goals. Despite this, with on-the-job training, generally school leavers are able to handle the mathematics forming an integral part of their daily workplace chaos.*

Ulric: *As students move out into the world of work, the value of having mathematics as a subject as one of the prerequisites for work takes on a role compelling individuals to become more knowledgeable and to seek help in attaining a passing grade. Therefore I do believe that they could handle the mathematics associated with workplace activities.*

Michael: *Although one encounters mathematics in all areas of life, it certainly aids in one's personal development and helps one to make critical decisions. The mathematics curriculum is allowing students to meet economic goals. Students setting middle school examination would have been prepared for life.*

My Interpretation of the Data

There is consensus among heads of mathematics departments, that 'on–the-job' training of students could have better prepared students to handle the mathematics at the various workplaces. However, on-the job training is not a tenet of the Secondary schools' activity system, nor is it a component of the school's environment. It is also training acquired after the students would have left secondary school. Hence I would argue that capability of students to handle mathematics in the workplace because of on-the-job training in fact may allude to the fact that the mathematics lessons in classrooms may be providing insufficient provision for students to handle mathematics in their workplaces upon entering the labour force immediately upon graduation.

Information Emerging from the Data

Having examined data, directly related to the research question from the school's activity system, the information emerging suggests:

1. The mathematics taught in the secondary schools of Antigua and Barbuda did not appropriately prepare school leavers mentally/psychologically for the workplace, since the content was not related to students' way of life.

2. The topics of the mathematics syllabus did cater for differences in career trajectories, while on-the-job training compensated for the school's inappropriate preparation of school leavers to handle the mathematics in the job market.

Consequently, employers were provided with employees who were in a position to handle the mathematics at their workplaces. Nevertheless, handling of the mathematics in the workplace was due to a source external to the mathematics being taught in the secondary schools of Antigua and Barbuda by mathematics teachers.

6.5.3 Examination of Data from Secondary School Principals

In this section I present responses to the first subsidiary question collected from two principals of the six secondary schools. Other principals were unavailable. The pseudonyms Sir and Madame were used to invoke the anonymity clause. These were the responses to the aforementioned question, *is the mathematics taught in the secondary schools of Antigua and Barbuda by mathematics teachers appropriately preparing school leavers to handle the mathematics in the job market?*

Sir: *Because of the lack of trained mathematics teachers, the poor mathematical content of teachers in the system, and the lack of skilful mathematics teachers, students quite often fail to see the link between mathematics taught in classroom and their daily life. Additionally because the mathematics curriculum is not one prescribed by the school it really does not cater for preparation of students for the workplace. Rather, it caters for those students following the trajectory of higher education. So here is the discrepancy.*

In fact, the relevancy of the mathematics learned in the classroom for students' ability to handle mathematics in the job market is solely dependent upon the personality of the teacher. In terms of those students who are going directly to the workplace, I don't know if there is that connection made with the mathematics that students will be called upon to use in the workplace and the mathematics learned in schools.

Especially since I do not believe that the mathematics curriculum in use in our secondary schools is providing students with requisite skills for the work place. No link! The mathematics curriculum in use is bias towards academicism, and further studies in higher institutes of learning. Furthermore, the main focus of teachers teaching mathematics is one of completing a syllabus; without due care given to ascertain whether or not mathematical growth takes place, foundation is laid, if students are being reached at their level, or if the pace at which students are asked to inculcate and to make meaning of new mathematics concept is too fast. At the moment what we have is the focus in one area. This boundary has to be broadened to include other aspects of the professions in the job market.

Madam: *Yes I do believe that the mathematics curriculum is providing students with requisite skills for the workplace*. *It is further my claim that the mathematics learned in the classroom is preparing students for their future career trajectories. On the other hand I am also aware that there are some topics, for example, trigonometry that I don't believe students can associate with their career path. But there is a link, although not readily seen by the students…….but topics of simple interest, discount, the entire consumer arithmetic module provides such a link.*

My Interpretation of the Data

While I find the argument advanced from Sir's data to be creditable and having the necessary and relevant evidence to support his claims, I take an alternative view to

Madam's argument. For while Madam is convinced that the curriculum used by mathematics teachers in secondary schools of Antigua and Barbuda is appropriately preparing students to handle the mathematics in the workplace, my examination of other responses from Madam rejects her argument. I offer reasons for this view using the other responses from other questions during the interview.

Madam: *As teachers we teach the way that we were taught. We are prone to be syllabus driven. And because of that areas that I know from having done the diploma in teaching of mathematics that could motivate our students are completely not incorporated into our daily classroom practice. How interesting mathematics classes could become if only we would make use of the different teaching strategies; and all this would have been obtainable if only we had smaller class sizes. Our classes are slotted so tightly into a rigorous time table aimed at covering a syllabus that the time seems just not to be there to enjoy mathematics. We are even denied access to the computer room, where we could have introduced the children to the computer as a tool to be used in their mathematics experience, growth, and development.*

Madam: *Because of large class sizes, there is a reduction in the amount of interaction that could have been possible. Additionally we know that students have different learning styles and different learning abilities. But we are forced to give classes at the same year level the same examination at the end of the year. There is no room for readjustment of examination paper determined by students' capabilities or stage of progress. Recently there is the compulsory Caribbean Secondary third form mathematics syllabus that has to be covered. It comprises five models. Therefore teachers are always pushing concepts without opportunity to weigh how well students have grasped taught concepts. It is not right and it does affect end of year students' examination performance.*

***Madam**:* *During a mathematics lesson the classroom environment is unbearable. It is difficult to manoeuvre around the class because the space is too small for the large number of students. Working between rows of furniture, table, and chair, which are so tightly packed in is not easy!*

Madam: *Relevance of the mathematics learned in the classroom to students' personal experience? They live it, but still the mathematics vocabulary is not one with which they are acquainted. As teachers there is a need to introduce some mathematics vocabulary to complement the topics being taught.*

Madam: *Main focus of teachers who teach mathematics is to complete the syllabus*.

Comments

I argue that there could be no appropriate preparation of students to handle the mathematics at the work place using the mathematics classroom as the training centre. This could not have been plausible when Madam had spoken of the 'unbearable' conditions that exist in the mathematics class room during mathematics lessons, the small class space and the large number of students in each class (42); whole class teaching despite having students with different learning abilities, styles and pace of comprehension; teachers constantly 'pushing concepts without opportunity to assess whether or not taught concepts were understood by students' (participant); where some mathematics vocabularies associated with specific topics were not familiar to the students. Finally, tests used to assess appropriate knowledge of students were skewed from students being given a one size fit all test in the same year level, regardless of whether or not students had covered the said topics. Hence for reasons advanced in aforementioned responses and those listed here, I would argue that preparation of students for handling of workplace mathematics could not have been appropriately accomplished by mathematics teachers in the secondary schools

6.5.4 Evaluation of Students' Data

Although students probably would not have been in a position to speak with any authority on their preparation to handle mathematics at future workplaces where they would seek employment directly upon graduation from secondary school, it would have been equally reprehensible if students were not given a voice to air their experiences while learning mathematics in secondary schools' classrooms. It is my intention to use the data to extrapolate information as to the status of preparation accorded students for the job market.

An examination of the data collected from two research sites from students (section 6, p.) speak of no preparation for future role of mathematics in their career trajectories. Nor is there any mention of students visiting worksites, speaking with any employer or undertaking any practical aspect by way of a project or seminar for taught mathematics topics.

Rather we read of students being taught concepts in classrooms that are 'hard' to understand; that explanations of procedures to be followed in solving problems given by teachers are complicated and of teachers getting annoyed when students request a repeat of taught concepts which they did not understand. Even where we have students remarking that from ‘beginning to end him (the teacher) takes his time’ (students), do we read of any preparation accorded students for entrance into the labour market?

All that students are told and do know is that they need mathematics, to help in their matriculation or qualification for a good job. Hence I would surmise that appropriate preparation of students to handle mathematics in the workplace was not a main feature or an objective of teachers teaching mathematics in the secondary schools. In fact almost all of the heads of mathematics departments have claimed that the main focus of teachers is to complete the syllabus in their preparation of students to pass the final end of year CSEC examinations (section 6.5.2).

This is contrary to what obtains in Chennai in India (Researcher, 2004) where teachers were expressing having a member of staff assigned specifically to research mathematical requirements for students seeking to enter the job market immediately upon graduation. Given that the population in India is near the one billion margin, it makes it difficult for inappropriately prepared students to be competitive in the job market. In Antigua and Barbuda with a population of a maximum 100,000, this phenomenon does not have the same significance as in India. Hence inappropriate preparation is not targeted as closely as should be the norm. Thus by way of summarising this section, I would claim that the mathematics taught in the secondary schools of Antigua and Barbuda by mathematics teachers in some instances did not appropriately prepare school leavers to handle the mathematics in the job market.

6.5.5 Phase Two: Need for Change

This section examines data for the question: is there the need to change how mathematics education is being conducted in secondary schools of Antigua and Barbuda? I now provide responses to the question, from the participants of the teachers’ activity system, who were directly associated with the activity of teaching mathematics to students. First I examine responses from each of the six heads of mathematics department:

Ilma: *Change in the teaching strategy is required. At the moment teachers teach as they have been taught.*

Whitfield: *Need to change preconceived notion of students, of mathematics being hard*.

Gertrude: *Get students to change their ingrained thoughts of mathematics being a difficult subject. Also we should use different teaching strategies to cater for different learning styles and intellectual abilities of students*.

Cardinal: *A change in the present structure of curriculum to one that has a preamble to all topics; allowing for contextualization of topics. The topics should be related and based upon economic activities in the environment. The curriculum should also have a practical component.*

***Ulric**:* *There is the need for proper training of teachers who are dedicated to the mathematics discipline and the need to be serious about teaching mathematics.*

***Michael**:* *Improvement is required in upper classes. There is the need for students to function/operate as a team. More interest in the subject is required all around. It is my view that students' interests reflect teachers' interests and passion.*

Contribution from Principals

***Madam**:* *Get the application part. Most of teaching should be for discovery or creativity. I believe if students were allowed to pursue this path, they would see and appreciate mathematics better.*

Sir: *There has to be a focus at the primary level to ensure setting of foundation. So in terms of how mathematics is taught there is the need for more practice, and more practical aspect. Mathematics is being taught in too much of an abstract manner. There is a need to relate it to the students' everyday experience. Example, Pythagoras' Theorem, this should be given a practical component at every stage of the curriculum.*

A radical orientation must develop for a love of mathematics. The mathematics is hard syndrome must change.

Athena: *Classroom mathematics needs to, reach students where they are. I am not convinced that ……… classroom mathematics integrates enough of what students know and accepts it as worthwhile knowledge; or holds it up to see what parts of it, can be used. It starts a kind of this is what it is, don't question it. And I think it needs to integrate more of what students know, integrate students' experiences; use a variety; use different methods and then to cater for students who learn in different ways……….And the sitting and the doing of sums or the sitting and the listening to the teacher require these alternative approaches……….Allow the students to talk a little bit more; I think that that would………Especially when you get students to talk and to see some of the misconceptions they have………..Even, while holding……Even, even if they know what the rules are and they still hold on to these misconceptions because they never get* *aired to see what's wrong with them or what's right about them or anything.*

Students: *Reason(s) to the question: why are we learning this? Students should be given reason for learning every topic in the curriculum. Additionally where will the information be used, and what is its utilitarian value.*

These are the areas participants of the teachers' activity system have cited as their recommendation for changes. As the researcher my task is now to identify areas in need of change in this teachers' activity system. To accomplish this task I use contradictions using the Engeström (2010) discursive tables with its linguistic cues as the tool to help in the identification of these contradictions (see Chapter 4, section 4 p. 84).

6.6 Identification of Areas for Change

In this section I use contradictions to identify areas in need of change in the teachers' activity system. These contradictions are to be found in the discourses of participants (Engeström). The tool used to identify these contradictions is the Engeström's (2010) discursive table with its linguistic cues (see chapter 4). While there may be many categories under which contradictions could be categorized, by convention, four main categories are affiliated with this tool: conflict, critical conflict, dilemma and double bind. Linguistic cues specific to each heading allows for the identification of contradictions in the responses of my participants (Engeström, 2010).

6.6.1 Contradictions

> *Contradiction is a foundational philosophical concept that should not be equated with paradox, tension, inconsistency, conflict, dilemma or double bind since these were rather manifestations of contradictions and not synonyms. In organisational change efforts and interventions, contradictions were to a large extent manifested in discourses' (Engeström). They are demonstration of areas in the activity system in need of change. But in the absence of any systematic frameworks to identify the manifestations of contradictions in discourses the following tool was constructed (Engeström) to fill the gap. This tool is depicted in Table 6.2.4.*

This approach was applied in Peruski (2003) and Russell and Schnader Heinze (2005) studies, which compared and contrasted educators in terms of the contradictions identified in their systems. This is a new methodological framework employed for the identification and analysis of different types of discursive manifestations of contradictions. As I stated in Chapter 4, I use four categories of manifestations of contradictions to identify those in my data.

Since I need to identify what actually is the core of the contradictions, I begin with a definition of the term contradiction. I also attempted to show how well this proposed framework of discursive manifestation work in the analysis of my data from an organisational change intervention. I also tried to identify the kinds of dynamics that were to be found among the four kinds of discursive manifestations in a multiple case study intervention. Thus in development of my systematic conceptual framework, first, I define my understanding of contradictions. I make the crucial point that contradictions cannot be observed directly; they can only be identified through their manifestations. While Engeström (2010) has provided a formal scholarly definition of the term, my translation of its meaning is that in an activity system, contradictions represents areas in the system in need of change. These areas in need of change would have evolved over long periods, before reaching the point where change is required to maintain the stability of the system. Only a positive response to address areas in need of change could restore a harmonious and peaceful environment in which the organization could operate productively, efficiently and effectively. This meets criterion on which education decisions are handled in Antigua and Barbuda, since as a member of a regional group, consensus among member states is required for any major changes to occur in mathematics education.

This led to my characterization of the four important types of discursive manifestations of contradictions. I took these four kinds of manifestations and used them as the framework to analyse my data. I am aware that only a limited number of studies have made use of this framework. The most advertised used of the framework was its use by Engeström (2008-2009) in his analysis of data from a change laboratory intervention conducted with managers of the municipal home care for the elderly in the city of Helsinki in Finland. My usage of the framework will be on a much smaller scale. I proceeded with my analysis of my data in three steps:

1. First I analyse rudimentary linguistic cues that potentially express discursive manifestation of contradictions.

2. Second I identified and analysed the actual manifestations in my data corpus.

3. Third I bring the discursive findings together with a historical perspective on teaching of mathematics in Antigua and Barbuda order to identify and elaborate on organizational contradiction in this activity system.

   I begin the analysis with the examination of the responses from participants in the entire activity system associated with this first subsidiary question. Below I present the table with the discursive manifestations and their typical linguistic cues (Engeström, 2010) first introduced in Chapter 4.

6.6.2 Identification of each of the Categories of Contradictions

In this section I identify the contradictions found in the responses of all the participants in this teacher activity system. While we are naming this system the teacher activity system, it must be mentioned that there are several separate independent activity systems embedded dilemma within this system. However my focus is with the system informing teachers, principals, mathematics officer for secondary school and students. In this frame work while there are individual systems as claimed by Engeström (2009) it is the collective system which is paramount when using contradictions to identify an area for change in the system

With the aide of the discursive tool I have identified each of the categories of contradictions in the participants' responses to my research question. I now present tables with each category of contradictions identified in this analysis.

Manifestation of Contradiction: Dilemma

In Table 6.6 I have examined discourses of participants using the linguistic cues for dilemma and have identified them. They now form the content of the table. In addition to linguistic cues my identification of dilemmas was also based on my using a formula, where any statement sending a message of one being unable to achieve the mandated specified educational objective, would be classified as a dilemma. More analysis will be accorded on this data when all four categories of contradiction are identified.

Table 6.6: Manifestations of Contradictions for category of Dilemma

Participants	**Responses with Linguistic Cues**
Ilma	No it is not relevant to the students' experiences Also not a lot of it is relevant to everyday life. Gaining a grade 1-3 passing grade in mathematics, Basic level Proficiency was not accepted by the government or to private employers.
Whitfield	No, the curriculum topics taught in school do not allow for any relationship between the contents of the mathematics curriculum and students' way of life. Students associate the concepts taught with problems used to solve items in classroom or annual end of year tests. There is no link to any other of their real world experiences Students have a fear for mathematics.
Gertrude	Relationship between the content of the mathematics curriculum and the students' way of life…………they live it, but still the mathematics vocabulary is not one with which they are acquainted.
Cardinal	In our school system we practice using of our human resource for the wrong goals. The practical aspect of mathematics is not stressed. The syllabus does not have a practical component. Different trajectories are not fully covered by the CXC curriculum. There is a bias towards academicism.
Sir	The curriculum is not providing students with requisite skills for the workplace because there is no link! The mathematics curriculum in use is bias towards academicism and further studies in higher institutes of learning.
Conquistador students	Procedures used to convey mathematics algorithm are complicated.
Estella	Mathematics topics were too, too wide. Too much to learn at any one time. Just too much, we don't need so much.
Athena	I mean in terms of knowledge economy, I think our students leave school, those who pass the mathematics, with knowledge of the content, with almost no application of the skills and the things you want to go with it are almost not there!
Feature	Expression or exchange of incompatible evaluation
Resolution	Denial, reformulation

Manifestation of Contradiction in Secondary School's Activity system

Table 6.7: Manifestations of contradiction in Teacher's activity system-Conflict

Participants	Linguistic Cues
Cardinal	The mathematics curriculum in secondary schools is built to facilitate the interest of CXC.
Ilma	Users are not free to put whatever take they deem necessary in adjusting the prescriptive content of the curriculum. One has to be guided by CXC's examination requirements. It is not an open ended situation. It is guided and closed. We have to do mathematics that is not in the interest of national goals.
Conquistador Students	When teacher is explaining the lesson……..some teachers make it complicated and get mad/vex when you ask them to repeat.
Macedonia students	Students must listen……..and teachers have to listen too.
Edmund	Some children are practical learners. Therefore there was the need for more practical things to do. There was not any of that. I can't even say when I learned any of the mathematics I use. When I got home from school I was just always fixing bicycles, tires, and anything [at school] the practical component is missing.
Athena	No, no, ah man……….I do not believe that sufficient preparation was made to equip students for the job market. I think we use it as a carrot as to why they should do it. But I don't think that sufficient preparation is made in terms of the content outside off having careered days and so on, specifically for mathematics. I do not believe that the mathematics topics taught in secondary schools were preparing students with skills for the [knowledge economy] workforce. Ohm…..I still see mathematics too much as an individual exercise in school. Again this might not be the case in every situation and in everything. But there are some students who feel that if they can't do it by themselves, or working with others, which is something that being able to work as a team is very valuable in the workplace. But this is something that is not promoted in schools, to me <u>especially</u> in mathematics; because you must know how to do this. The other thing too, mathematics which seems to be a prime area for using some technology and so on……….still remains largely chalk-and-talk in schools. Yeah………ah mean………yeah, let me leave it there.
Resolution	**:** Finding a compromise. Submit to Authority or majority (Engeström, 2010).

Manifestation of Contradictions: Critical Conflict

Table 6.8: Manifestation of Contradictions: Critical Conflict

Participants	**Linguistic Cues**
Ilma	Although the basic syllabus was constructed for the sole purpose of linking classroom mathematics to the workplace mathematics routines, the marketing strategies defeated this purpose. Today it is characterized as the syllabus with no currency
Cardinal	Some of them may not even be mathematically inclined. It is students' lack of ability to cope with practices required for mastery of mathematics problems, and to complete SBAs in the other subjects. The load is just too heavy!
Michael	Since the main focus of teachers is to finish a syllabus, while teaching mathematics lessons, where the task is one of preparing students to write an examination, I am not sure whether or not students see the connection between mathematics taught and learned in school and their future career trajectory.
Sir	In terms of students who are going directly to the workplace, I don't know if there is that connection made with the mathematics students will be called upon to use in the workplace and the mathematics learned in school. (1)
Conquistador Students	Some students are rude……… Mad! And just don't want to pay attention……….I just feel lost, bored, alone. (2)
Macedonian students	Some students talk, disrupt the class, rude, and look bored. (1)
Estella	All the maths I am doing here when not using computer software, is just basic
Edmund	The teaching was full of too much theory. The practical component was needed
Athena	Classroom mathematics needs to, I think, reach students where they are. I am not convince that classroom mathematics integrates enough of what students know and accepts it as worthwhile knowledge; or holds it up to see what parts of it can be used. It starts a kind of this is what it is, here it is; don't question it, and I think, it needs to integrate more of what students know, integrate students' experiences, use a variety; use different methods and then to cater for students who learn in different ways………….. And the sitting and the doing sums or the sitting and the listening to the teacher require those alternative approaches…….
Feature	Facing contradictory motives in social interaction; feeling violated or

	guilty.
Linguistic cues	Personal, emotional, moral accounts. “I now realize that…….. (Engeström).
Resolution	Finding new personal sense and negotiating a new meaning (Engeström).

Identification of Manifestation of Contradiction: Double Bind

I have defined *double bind* as educational practices and policies over which practitioners/teachers in this case, have no control. Nevertheless these practices and policies are in need of new approaches to be beneficial to the education system.

Table 6.9: Identification of Manifestation of Contradiction: Double Bind

Participants	**Linguistic Cues**
Ilma	In creating a syllabus there is need for additional information to enable this to be realize
Gertrude	There is the need to introduce some mathematics vocabulary which is relevant to the various topics to be covered
Cardinal	Curriculum in use in school should have been more practical based. It should have had a component prerequisite, where discussion of topics must be a part of each topic. So for example, in teaching of quadratic equations , there could be a discussion about missile, relate it to work before getting into learning of algorithm associated with working of class room mathematics exercise problems.
Ulric	The content of the curriculum does not address the different trajectories of students all the time. There has to be a connection and cohesion [between] topics. This is lacking. Operating in a system where placement of teachers to teach a particular year group is done randomly; so that teachers might not be teaching the same students from one year group followed by the succeeding year, one cannot hope for continuity
Sir	Sometimes the relevance of the mathematics learned in the classroom is solely dependent upon the personality of the teacher.
Conquistador students	If teachers ask us to wait until after class or to come at another time outside of this session that would have been a better approach when as students we ask for a repeat of taught concepts. A passing grade in mathematics is necessary to get a good job.
Macedonian Students	Where students are disrespectful teachers ask them to leave the class.

Table 6.10 Identification of Manifestation of Contradiction: Double Bind (Continuation of Table 6.9)

Participants	**Linguistic Cues in responses of participants**
Estella	Teaching of mathematics topics needed to be more specific.
Edmund	How I approach a problem: If I can't see it, I call other people and tell them to give me their opinion.
Michael	It is the volume of work that has to be covered that presents students with a problem.
Athena	There was a secondary school which I was going to, where I used the software Geolgebra to deliver a lesson on quadratic graph; you know the shape of the graph and what happens at different places. I wanted to put it into schools' computers that the students could have actual hands on experience in using that and was told that the students had to sign a contract to state that they would use the I.T. room only for I.T. and not for anything else. So it would need a rethinking on the part of the school organisations. Allow the students to talk a little bit more; I think that that would.........especially when you get students to talk and see some of the misconceptions they have............Even, whilst holding.......even if they know what the rules are and they still hold on to these misconceptions because they never get aired to see what's wrong with them or what's right about them, or anything.
Madam	I am aware that there would be some topic, for example, trigonometry which [some] students cannot associate with their careers.

Using the definition for this particular contradiction and its associated features, I identified additional areas in the responses of participants where contradictions associated with *Double Bind* were located. The significance of this act was to help with the identification of areas in the education system informing mathematics education that could be in need of change(s).

Features: Facing equally and pressing unacceptable alternatives in an activity system (Engeström, 2010).

Linguistic cues: “We”, “us”, “we must”, “we have to”, pressing rhetorical questions, expressions of helplessness (Engeström, 2010).

Resolution: Practical transformation (going beyond words) (Engeström, 2010).

6.7 Summary

In this Chapter, which is the first of three analysis chapters, I present data associated with the school’s activity system. I offer information as to methods used for collection of data. Additionally, I offer rationale for my constructed questions and for the use of specific questions for obtaining data from participants. I also present the time table governing the period of data collection. I use data collected from heads of mathematics departments, Mathematics Officer secondary schools, principals of secondary schools and students (present and former) to present suggestions to one of two subsidiary questions*: is the mathematics taught in secondary schools of Antigua and Barbuda by mathematics teachers appropriately preparing school leavers to handle the mathematics in the job market?*

Using the five principles underpinning activity theory, the second generation Engeström (2001) Cultural historical activity theory (CHAT) triangular configuration and its elements, contradictions and the associated discursive tables with cues for identification of four categories of contradictions, I identify areas in the system, in need of changes, using the responses of participants. Interpretations are offered for information emerging from the data. Suggestions are advanced which claim that the mathematics taught in schools have not appropriately prepared school leavers for the workplace.

Chapter 7 - Impact of Employers' Mathematical Needs

7.1 Overview

In this chapter, I address the second subsidiary question: what is the impact of employers' mathematical needs on mathematics education in the secondary schools of Antigua and Barbuda? To accomplish this, I analyse how the mathematics qualification for the newly employed, demanded by employers, impacts the learning of mathematics in schools. I also examine the role mathematics education is expected to play in job creation, in reducing youth unemployment and in national development. Consequently, I assess the relevance of the mathematics content taught in school, in the context of these expected roles.Subsequently, I offer suggestions as to how detailed understanding of what mathematical competencies workers require on the job, could be utilised to improve the quality, the effectiveness and the efficiency of how mathematics is taught in secondary schools. Lastly, I analyse the factors required to motivate students to work harder, to achieve mastery of the relevant mathematical skills. I use the data I collected from my research of the mathematical needs of a sample of employers' worksites, in collaboration with data recently collected by United States Agency for International Development (USAID) on labour market conditions in the Organisation of Eastern Caribbean States (OECS) to accomplish my analysis.

7.2 Introduction

Employers are included as one of the main *Subjects* of the education management activity system developed in Chapter 4, first, because of the critical incentive, securing employment provides to students, in their efforts to be successful in their studies and secondly because of the high level of youth unemployment. Indeed, the creation of employment especially for youth, the need for employees to increase their trainability and to develop the capacity to master higher levels of technical skills, are critical requirements for national development. Mathematics education is one of the most important subjects in realising these two objectives.

7.3 Structure of the Antigua and Barbuda's Labour Force Sectorial Employment

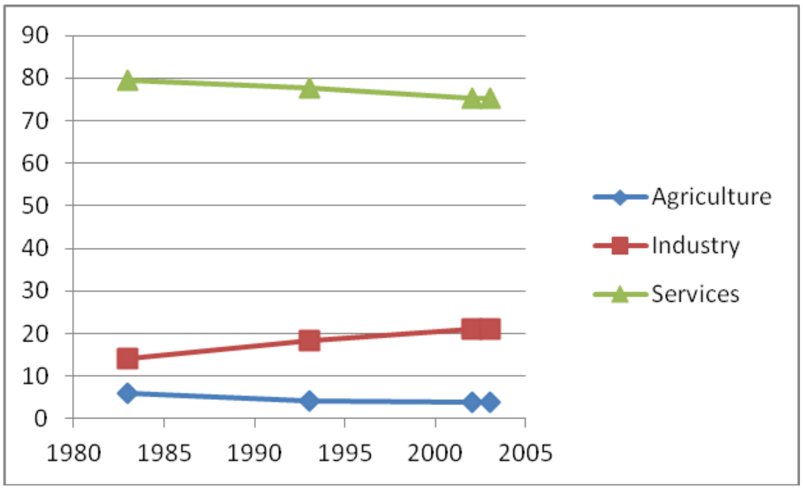
In this section, I introduce the sectors of the economy where students graduating from schools could find employment. As listed in **Table 7.1** the sectors are: agriculture, industry and services. I provide information for different years indicating the contribution of each sector to the labour market. I then devote the remainder of the analysis to describe the composition of the labour force.

Table 7.1: Structure of the Economy 1983, 1993, 2002, 2003

Source: World Bank, 2008. "Country Assistance Strategy for the Organization of Eastern Caribbean States"

Years/Categories	1983	1993	2002	2003
Agriculture	6.1	4.1	3.8	3.7
Industry	14.2	18.2	20.9	20.9
Services	79.6	77.7	75.3	75.4

Graph 7: Spatial representation of data in Table 7.1



According to the World Bank (2008) the public sector in Antigua and Barbuda comprises approximately 40% of the 36,000 people that make up the labour force, one of the highest proportions in the region. These employees are roughly equally divided between civil servants and non-established workers. Direct employment in the hospitality industry currently comprises 23% of the labour force. The last census conducted in 2001 indicates that approximately 5,000 people were employed by hotels and restaurants. Data collected from 2011 census is still not yet available. A proposed labour market survey is still outstanding (United States Agency for International Development, 2011).

7.4 Importance of Securing CSEC Mathematics Pass

Mathematics and English are the two compulsory subject employees demand for white collar jobs. Most vocational schools also require mathematics and English as their entrance requirements. All academic tertiary institutions require both mathematics and English as part of their five CXC CSEC levels entry requirements. Furthermore, employees who have mathematics and English are prioritised for on-the-job training (USAID, 2009). Achieving CXC CSEC levels mathematics qualifications is therefore of fundamental importance to the employment and professional path chosen by graduates. In **Table 7.2** I highlight the data required for entrance to post-secondary school education in Antigua and Barbuda. However, for those graduates entering directly into the job market, qualifications for job market employment are communicated via: the Human Resource Departments for the various worksites, www.caribbeanjobs.com, antiguaobserver.com, local newspapers and the Organisation of Eastern Caribbean States Secretariat, in St Lucia, Establishment Department and the Caricom Secretariat, in St. Lucia.

Table 7.2: Entrance requirement to vocational and tertiary institute

Vocational or Tertiary program	Number of CXC Subjects	To Include
'A' Level Department	5	English and mathematics
Antigua and Barbuda Institute for continuing Education (ABICE)	-	Transcript from last Institute of learning and an identity card.
Antigua and Barbuda Training Centre	-	Administered placement test
Antigua and Barbuda Institute of Technology and Training(ABITT)	5	English and mathematics. Subsequently A placement examination
Engineering and Construction Department	3	English, mathematics, physics or a technical subject
Business Department	5	English and mathematics
School of Nursing	5	English, mathematics and a science
Department for the University of the West Indies	5	Several Modules from A' levels department with specificity to desired area of study.
Teacher training department	5	Core subject areas: English, mathematics, a science subject and a social science subject. They must have done: A' level and attained two units in the subject that they are going to be teaching.

7.5 Employment and the Labour Market

In Antigua and Barbuda, most students go to school because it is the culture of this society. It is also the institution given the responsibility to provide graduates with qualification for matriculation to the job market and tertiary education. In my thesis the focus is on those graduates entering directly into the job market. The labour market in Antigua and Barbuda has seen serious and growing unemployment since 2009. While a formal unemployment survey has not been carried out by government, data from the Social Security programme, (a mandatory pension scheme for all employees) indicate that over 30% of their contributors are now unemployed: 2009 to 2012 (Social Security, 2012). The International Monetary Fund's (IMF) Article IV Data (2012) on the performance of the Antiguan and Barbuda's Economy indicate the economy has had a cumulative negative growth of 25% from 2009 to 2011. Youth unemployment has always been much higher than average unemployment. In fact, **Table 7.3** demonstrates unemployment by age group in the OECS. Correction of this high level of unemployment among youth is a national priority in efforts to revive economic growth.

Table 7.3: OECS: Towards a New Agenda for Growth 7 April 2005

Source: Organisation of Eastern Caribbean states OECS:

Countries of youth unemployment	Tear of source Data	Yearly Youth Unemployment	Yearly Adult Unemployment	Youth share of unemployment
Antigua and Barb.	1991	13.0	4.2	47.0
Dominica	2001	56.0	16.7	50.1
Grenada	1998	23.9	9.2	49.0
St. Kitts and Ns	2001	11.0	3.6	44.0
St. Lucia	2001	36.8	11.7	48.6
St. Vincent and the Grenadines	2001	39.4	15.3	45.3
OECS		**31.9**	**10.8**	**47.6**

Employers have published in the employers Federation quarterly Journal, Gazette of Antigua and Barbuda, Local newspapers and aforementioned areas cited in section 7.3, paragraph 2 and their qualification requirement needs for students leaving secondary school. The Civil Service, including the teaching profession requires five CSEC levels including mathematics and English; the civil service provides at least 20% of all jobs in Antigua and Barbuda. Most other White collar jobs have the same requirement as the government's public service.

Profile for skill areas where employment is available includes skilled vocational graduates and professional and managerial areas (USAID, 2012). Access to training in these areas requires students to have mathematics, English and three to five CSEC level subjects. This again points to the pivotal role of mathematics education.

On securing both employment and tertiary training for school leavers upon graduation from secondary school subsequent to entering the job market or tertiary institutions.

High tech economic activities are regarded as having the best potential for new job creation (International Monetary Fund, 2011). Activities in the offshore sector, in niche export special commodities, in tourism and export agriculture, all require technical know-how, professional services and advanced computer skills. Again, these require mathematics as a basic qualification to access the tertiary training required to fulfil the employment needs. Presently as demonstrated in **Table 7.4** below, most students leave school having attained only a Grade 5 level pass in mathematics. This profile indicates that these students 'show a limited grasp of the key concepts, knowledge, skills and competencies required by the syllabus: no knowledge of the subject and lack ability to reason or comprehend mathematical concepts' (Caribbean Examination Council, 2013).

Table 7.4: Profile of School Passes in Mathematics 2000 -2012

Schools	**Mean passes**	**profiles**	**Median No of students**	**Median (%)**	**Median Profiles**	**No. Of Students (%)**
Alexander	12	G_6	25	3.5	G_5	416(58%)
Excelsior	80	G_2	108	14.4	G_2	241(32%)
Socera	75	$G_{2/3}$	54	7.7	G_3	257(37%)
Aristotle	12	G_6	26	4.5	G_5	182(38%)
Macedonia	8	G_6	37	6.8	G_5	260(48%)
Thessolonika	15	G_6	29	3.5	G_5	484(59%)
Phillip	8	G_6	15	3.4	G_5	237(54%)
Conquistadore	26	G_4	41	4.5	G_5	532(59%)
Siboney	1	$G_{2/3}$	2	2.5	G_5	65 (82%)

This data reveals that only 2/9 (22%) of schools have no students in profile of G5. For all 0f the seven other Government schools, mathematics knowledge falls in the Grade 5 profile. These are the people who after graduation usually enter directly into the work force. With the demand for high level skills and passes in mathematics (World Bank Researchers, 2007) there is need for serious remedial work in mathematics and for a revolution in how it is taught in schools in Antigua and Barbuda

Table 7.5: Official Interpretations to be Applied to the Profiles Indicated in Table 7.5

Source: Caribbean Examinations Council, 2013. Caribbean Secondary Education Certificate (CSEC) Preliminary Results Slip

Categories	Interpretation
General Proficiency	Connotes subject activity designed to provide a foundation for further studies in the specific subject area beyond the fifth year of secondary
Grade 1 (G_1)	Candidates show a comprehensive grasp of the key concepts, knowledge, skills, and competencies required by the syllabus.
Grade 2 (G_2)	Candidates show a good grasp of the key concepts, knowledge, skills, and competencies required by the syllabus.
Grade 3 (G_3)	Candidates show a fairly good grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
Grade 4 (G_4)	Candidates show a moderate grasp of the key concepts, knowledge, skills, and competencies required by the syllabus
Grade 5 (G_5)	Candidates show a limited grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
Grade 6 (G_6)	Candidates show a very limited grasp of the key concepts, knowledge, skills, and competencies required by the syllabus.
Profile Grades	A – outstanding; B - good; C – fairly good; D – moderate; E=weak; F – poor.
Mathematics Profile	Subject profile – General Proficiency; Grade Profile - Knowledge, Comprehension and Reasoning.

Over the past twelve years, 2000 – 2012, approximately 70% of the Antigua and Barbuda school graduates have left school, joining the work force with either (a) a 'limited or (b) a very limited grasp of the key concepts, knowledge, skills and competencies required by the mathematics syllabus' (official interpretation for the profiles classifying performances of graduates using the mathematics passes achieved by students, G5/G6). Hence, in my evaluation of the techno-mathematical literacies skills and knowledge of the labour force in Antigua and Barbuda, one of the quintessential factors required by employees for the 21st Century and beyond, I would argue that the graduates from the Antiguan and Barbudan Education system have not been appropriately prepared to handle the mathematics in the workplace. Today's employers are looking for a very different skill set compared to the past, as demonstrated in **Table 7.6** below:

Table 7.6: Priority Skills Demanded by Employers, USAID, 2011

Priority skills demanded by employers' sector	**Type of Company**	**Priority Skills in demand**
Tourist/ Hospitality	Hotels	1. Technical-occupation specific 2. Customer service 3. Supervisory 4. Communications 5. Computer literacy
	Restaurants	1. Management 2. Supervisory 3. Customer service 4. Culinary 5. Communications
	Tours	1. Customer service 2. Communications 3. Computer literacy 4. Marketing
	Crafts	1. Woodworking 2. Metal working 3. Painting
Agriculture	Crops	1. Equipment operation 2. Seed technology 3. Agro-research 4. Agronomy
	Fisheries	1. Fiberglass repair 2. Marine Engineering 3. Marine biology
	Agro-Processing	1. Mechanical engineering 2. Microbiologist 3. Machine operation 4. Marketing
Information or communications Technology	Telephones	1. Technical-occupation specific 2. Customer service 3. Management 4. Marketing
	Computers	1. Technical-occupation specific 2. Communications 3. Marketing 4. Customer service
Construction		1. Carpentry 2. Masonry 3. Plumbing

Training on the job is a possible source of upgrade for employees but data show employees are more likely to train secondary school graduates with mathematics, English and several CXC subjects (USAID, 2011). Job is a possible source of upgrade for employees but data show employees are more likely to train secondary school graduates with mathematics, English and several CSEC subjects (USAID, 2011).

7.6 Jobs accessed without CSEC Mathematics Qualifications

There are many areas of employment in the economy of Antigua and Barbuda that secondary school graduates can access, without CSEC levels mathematics qualifications. Most of the secondary school graduates work in these jobs and many do not view mathematics as important or relevant to their future job prospects. With mathematics being compulsory, as is English in all secondary schools in Antigua and Barbuda, all students must study mathematics and prepare. Many students drop out without reaching fifth form and many seek mathematics training after graduating from school. When the drop-out rate is 11% combined with the mathematics failure rate at CSEC levels, the vast majority of students (over 60 %) leave secondary school in Antigua and Barbuda without CSEC level mathematics qualifications.

The jobs which can be accessed without CSEC level qualifications include: some vocational trades, where apprenticeship training is still available for those students who want to move up the vocational expertise ladder; construction, mechanic, equipment operations, taxi drivers operations, truck and bus drivers' enterprise, the wholesale and retail trade as sale representatives, the cashiers' job, the hotel sector as waiters, cooks, grounds' men, head of housekeeping department, water sports and in maintenance; government public works and non-establish public sector workforce, which is about the same size as the civil service (20% national workforce); entrepreneurship, micro-businesses, huckstering, farming, fishing, music, cultural activities, art, beauty care, nursery and preschool operations, security - private and public, to include the army and the police force.

In these areas, while mathematics CSEC level qualification is not a barrier to gaining employment, many of these jobs require knowledge and competence in several areas of mathematics. The economy cannot grow without these sectors growing and without workers in these areas being efficient, capable of absorbing new knowledge and innovations on the job.

Students should be equipped with mathematical knowledge relevant to the jobs that are available in the economy. Students who are highly motivated by the prospects of getting a good job should also see the relevance of mathematics they are taught in school to potential areas of employment. It is therefore important that the school's mathematics curriculum provides for this; as well as ensuring that there is for students the appropriate training and information sharing, in terms of available jobs, and their mathematics requirements. This could cause the transition from school to work to be more efficient.

In an effort to assess the relevance of the mathematics curriculum and the mathematics requirement for most jobs, which secondary school students normally access, I carried out a review of a sample of work sites to map the mathematical knowledge required to efficiently perform these.

7.7 Worksites Data Collection

Several workplace sites were visited in this research including:

- Six hotels
- A private utility, power plant
- The meat, vegetable, fish and craft markets
- The customs department (see video)

7.7.1 How I Collected and Used the Data

The sites were chosen since work carried out in these enterprises are typical of the range of work available in Antigua and Barbuda that can be accessed by secondary school graduates, most often without any CSEC level mathematics certification. The power company has several divisions that support its core business which allowed coverage of several skills in a single enterprise.

My main focus was obtaining information on present mathematical issues experienced by participants while performing their daily routines. At workplaces participants seemed candid in their responses to my questions. There was an air of confidence, assertiveness and of being well-informed on procedural matters informing their roles. Multiple corroborative interviews were held to ensure the validity of the responses and various documents were accessed to further support information collected from participants.

I collected the data by asking each participant at their workplace to give me an example of their typical workday activities. I knew that there was a fear for mathematics and that some of the managers had conveyed the message to impute that I was looking for the mathematics in their work. That was true. But I alleviated their fear when I said to them, just give me your story and I will take care of the mathematics. Taking care of the mathematics involved assigning the relevant branches of mathematics that would have been associated with the statement informing the activities of their typical work day.

So for example, when the chef said: 'my day starts at 6 O'clock and ends at 9 o'clock (Zac), I would then assign the mathematical topic: *time.* Additionally, when the chef reported that in the dining room, the size of the dishes and the cutlery could have served as a good indicator of the meal in progress, because of the size of the plates, I then classified this as the branch of mathematics captioned: *measurement.* The same procedure was used with the information from the head of the house keeping departments, entertainment officer, employees in the garage, accountants, manager of the privately owned utility plant and each participant that contributed to the data in this section.

7.8 Research Data from Employers

In this section I present the data collected from the employers and employees at workplaces of Antigua and Barbuda. My aim was to identify the nature of the mathematics informing workplace activities in the twin island state and then ultimately to assess whether or not school leavers proceeding directly to the job market subsequent to graduation were appropriately prepared to handle the mathematics at their worksites. Data were collected from the: manager of a private utility power plant;

employees at a garage; heads of housekeeping departments; human resource managers; hotel managers; gardeners; construction workers; entertainment managers; chefs; pastry chefs; accountants; receptionists; maintenance department shop and front desk operators. The data now provides content for the remainder of this section.

7.8.1 Private Utility Power Plant

The private utility power plant operation involves a wide range of jobs. This was an advantage which allowed an examination of the mathematics involved in a wide range of roles. The business comprises: Mowing of 150 acres of grass land, garbage collection, security, gardening, recycling plant, osmosis plant; also supplying electricity, water, telephone and IT services to all the homes and the hotel on the private island of Jumble Bay; a shop for mechanic parts; a garage and a construction site.

7.8.2 Mathematics Embedded in Work

From observation there were several categories that one could have assigned to the mathematics present in this workplace. In my visit with the plant manager to the Osmosis Plant, this was how he described the mathematics found in its operations**:**

> *The mathematics was not sophisticated - mainly measurement. Here mathematics was used to monitor all the water made; to measure the reverse osmosis plant; to monitor the power consumption it takes to make the water. This consumption of power could fluctuate when and wherever there were changes in the operating parameters. If there was no measurement then this could have resulted in wastage.*
>
> *Where its operation entailed the making of fresh water from sea water, measurement was also involved. The measuring process involved one of measuring the conductivity of water. The mission was to test for the presence of salt (Manager).*

Comment

The mathematics that employees would have been expected to perform included algebraic simultaneous equations, since there were several variables in operations simultaneously at any given moment in the plant’s procedural, processing work of eliminating the salt from the sea water to render it applicable for human consumption.

There was an interdependent relationship with the performance of each variable. No one variable could have caused the result required for the process of extracting salt from sea water; or in the treatment of returned water to be made into renewable products. The successful operation of the process was dependent upon the work of several variables functioning at the same time. In mathematics, this falls within the parameter of simultaneous equations. Additionally, arithmetical conversion, mathematics associated with chemical equations, indices and statistics also formed part of the component of mathematics required in the operations at this osmosis plant's work site (Manager). The new employees did not have to perform the simultaneous operations or other associated mathematical operations physically or mentally. These were embedded in the technological tools and machines used to facilitate the operation of converting sea water to fresh water (desalinating plant).

Association of the mathematics involved here would place them in the: algebra, consumer arithmetic, statistics and measurement content of mathematics taught from the secondary mathematics curriculum used in school. However, because the link had not been made by teachers to the nature of the mathematics learned in school and its workplace functioning, many employees could not identify the mathematics in their daily work routine. However, taught mathematics principles in these topics in school could have prepared students to handle the nature of the mathematics, provided students had learned what was taught (Caribbean Examination Mathematics Syllabus, 2010, pp.18-27).

Generators

There were four generators in the control room. In one panel, the operation included the measurement of the: voltage, ampere, frequency in hertz, power in kilowatt, monitoring of hours and of temperature.

> *The frequency of voltage figures in kilowatt assisted in monitoring wastage of water (Manager).*

Monitoring, measuring, and subsequent provision of figures from the generators indicated how the machines were performing, and whether or not diesel fuel used in making electricity was being wasted or was being converted into the desired electrical energy. Additionally all water sent around the island had to be measured at the end of each month to ascertain how much was made and how much was sold (Manager).

This involved calculation and arithmetical operation on numbers. Additionally, employees were required to have an appreciation and knowledge for the place values of numbers, where reading of water metres was part of work; since water pumped around the island had to be measured and balanced.

This task provided information of how much water came back for recycling and what was the recovery rate. The mathematical operation afforded knowledge of whether there was a profit or a loss from the plant's operations. The arithmetical operations for profit, loss and percentage played a pivotal role in these operations (Manager).

Garage/Maintenance - Parts Department

During my conversation with the mechanic I observed that the mathematics involved in work included:

Measurement for helping with the correct and specific sizes of parts needed for the fittings on vehicles;

Conversion in metric, millimetres, and imperial measurement;

Capacity; when changing oil of a vehicle employees should have knowledge of the volume of oil removed and therefore the volume of oil that has to be replaced. Not sufficient: too little or too much could damage the machine (Rayland).

Housekeeping/Laundry Department

This is the largest department in the hotel's labour force. In this report the *Laundry department* will be the main focus of the presentation. A synopsis of operation at this site began by way of announcing the arrival of the laundry linens. From here the mathematics embedded in work began to make its presence known. The very first action engaging the staff in this department was weighing of the clothes. Hence scales are important; so too were charts for United States (U.S.) unit of measurements. Once the clothes were weighed then the process of sorting of linen took place (Wendy). Hence the mathematical branch of *set theory* was employed.

Subsequent to sorting of linens, it was time to make several decisions. Some of the decisions included:

- Choice of electrical machine to be employed;
- The type of detergent required;
- The temperature required for washing the laundry;
- The volume of water required;
- The cleaning mechanisms to be employed;

In the forthcoming paragraphs reasons were advanced justifying the requirement of these decisions.

The decisions taken were based on the following components informing work in this department*:*

Temperature

This became the focus where different varieties of fabric were involved. Hence one of the employees' jobs entailed having knowledge of the right temperature required while washing each of the different texture of linen.

Weight

The weight of the linen was knowledge required by the employees. This was necessary since using the technologically equipped washing tools required a restriction on the poundage, if there was to be no harm brought to bear on the equipment (Manufacturer's information).

> *Estimation and guessing were not permitted since the managers' and employees' roles were to avoid undue damage to the barrels controlling the activities of the washing machines (Wendy).*

Size and time

Correct choice of which machine (50 lbs. or 120 lbs.) was to be employed during a specific operation could have eliminated wastage, while simultaneously maximizing the time for completion of a task, were decisions that had to be made by employees. Therefore:

> *The weight of the garments were important factors in determining the choice of washing machine employed with the goal of maximizing profit and cutting waste (Wendy, 2009).*

Comments

There was more diversity of the mathematics involved in the work of this department, when the comparison is made with other departments in the hotel industry. One such area was in the construction of the workers' schedule (manning in some departments). The mathematics employed on this occasion included combination and permutation. Combination and permutation became part of the operation when the head of housekeeping had to determine how to schedule each employee daily, weekly, and monthly; also where she had to allocate the location where each employee would be deployed on a given day and at a specific time. This operation also involved alternating employees' time for reporting for duty; morning shift: 6am-2pm, the afternoon shift: 2pm-10pm, or the grave yard shift: (wee hours of the morning, 10pm-6am). Subsequently, permutation too had to be a part of the operation: this enabled the head of housekeeping to introduce what in her opinion was the best fit for having each employees grouped with a set of other employees, as well as simultaneously ensuring that equity, fairness and equal workloads were allotted when constructing a roster for a specific time of the year. This information provided statistics for the number of employees that would have been required to fulfil vacancies for the activities in the:

- *Office*
- *Rooms*

- *Public areas, example, rest rooms and restaurants. The calculation was based on rate of occupancy of the hotel: high or low* (Wendy).

Equally, the time in which work was performed was important for the calculation utilised while setting the final rota:

> *Public holidays plus vacation time had an impact on the decisions that had to be made. For example, hourly pay for normal working days and working days on a public holiday were calculated at a different hourly rate. For public holidays the hourly rate would have been calculated at a rate of double times ordinary hourly rate. Therefore, the overall budget available for the department had to correlate with the number of employees that would have been scheduled to work within the specified time (Wendy).*

Hence even the construction of the workers' time table (roster) for work was based on mathematical calculations (Consumer Arithmetic).

I observed that the employees were huddled in a little circle and engaged in conversation. Several buckets fill with a mixture of sand, cement and stones/aggregates were on hand. Other buckets were filling with water. Some mixing of mortar had taken place and blocks were being laid and placed within the structure with attention, caution and skill.

Focusing on the activity needed to arrive at the number of blocks that was required to complete the project with only a one time purchase in the workplace, had three ways in which this could have been addressed. This could have involved the use of a:

> *Tape measure to find the area of the site*
>
> *Techno-mathematical tool to arrive at correct number of blocks, once the customer had provided relevant information for the area and perimeter of the plot.*
>
> *Multiplicative algorithm: multiplying the figure for the number of blocks in the length of the wall by the figure for the number of blocks in the height of the wall (Employees).*

Hence using my school's equation I arrived at:

Number of blocks = an x b,

Where *'a'* represented number for blocks in length of wall and

'b', the figure for the number of blocks in the height of the wall

However at no time did I see any of the employees with pen, paper, pencil or calculator. Neither was there a visible equation. Once again in the employees' view this was an activity that was performed using certain amount of ingredients. Whereas in school, theoretical information would have provided figures for the combination in which mortar's strength would have been guided, (1:2:3/2:4:6) here, it was now an operation. Hence judgement, intuition, and the eyes (sense organs) were crucial for the success of the operation. Additionally, employees were aware of the alternative methods that could have been employed to arrive at the same outcome.

In general students in classrooms were asked to use *only* the algorithm taught in class by the teacher. Here in the workplace, work activity was informed by corporation, collaboration and team work among the employees; the utilitarian aspect of mathematics was used to accomplish the mission for this activity.

School leavers entering directly into the workplace would have taken a while to acquire this level where workplace activity could have been transformed into an operation. However the value of teamwork allowed for the newly employed to adapt to the genres associated with workplace activities. Shadowing would best describe the role of school leavers at this job site. Indeed:

> *While some students can see the world of mathematics, I am not sure that all students see the content of mathematics as necessary or the qualification of mathematics as necessary for what they want to do..........and I think that it is that which hinders some students; because even though they see the qualification as being somewhat necessary, because they do not see the usefulness in what it is they plan to do; may be to become a mason, but don't know how the mathematics comes into it, then they kind of not pay attention to it , even though they have a fuzzy awareness of the fact that they might need the information (Athena).*

Additionally, division of labour would have allowed the school leavers entering directly into the workplace to hold their own, being assigned task that would have been within their grasp. For example, sifting of the sand, filling of the buckets and even having a turn at blending of the aggregates in the execution of a task here at the worksite could be described as elementary activities and therefore within the grasp of newly employed to show mastery of these activities.

All these activities I observed in the Antigua and Barbuda worksites were consistent with a lot of the workplace literature (Jorgensen, 2010, Wake, 2011, Williams and Wake, 2007). In fact the activities did in fact corroborate Evans (2008) claim of non-transferability of classroom mathematics to the workplace. Because the workplace has very different mathematics when compared to classroom mathematics, some of the employees were not even aware that they were performing mathematical operations. In the workplace, mathematics pedagogy took the format of an activity. Hence the findings of my research are supported by the work of scholars in this field of workplace mathematics.

7.8.3 Findings

In this section I present findings of the nature of mathematics at each work site. I also evaluate the mathematical content knowledge of each participant/employee.

My analysis of the data revealed that at each worksite mathematics was present in each activity that kept operations functional. However no two worksites had identical mathematics content. Therefore my analysis included the identification of the mathematics found at each work site, linkage to the content informing the mathematics lessons while using the secondary mathematics curriculum and suggestions as to whether or not this mathematics content would have allowed newly employed to be appropriately prepared to handle the mathematics in the job market.

In Table 7.8 – Table 7.14 I identify the subtopics in the secondary school's mathematics curriculum which could have allowed employees to acquire the content of the mathematics they were now using in the workplace. I also advanced suggestions, as to whether or not employees leaving directly from school would have been able to handle the mathematics in their work. The analysis was based on my knowledge of how mathematics was taught in school and the environment in which learning took place. My knowledge of the strategies and tools, used in communicating mathematical knowledge to the learners helped in my arriving at the specific suggestions. Information forming analyses in this section were from: (i) the osmosis plant (ii) the garage (iii) the laundry department and (iv) a construction site. Barring the laundry department all other worksites comprised sections from the management of the private utility plant.

The Osmosis Plant

In this table I highlight the tools, Operations Branch of mathematics associated with the activities at the osmosis plant operation. The operation involves conversion of sea water to pure drinking water. The main activity involve is removal of the high concentration of salt from the water.

Table 7.7: Findings from the Osmosis Plant's Worksite

Categories	**Findings from the Osmosis Plant Site**
Tools	Generators
Operations	Monitoring of water; monitoring voltage in kilowatts; lack of monitoring could result in wastage of the manufactured products; application of measurement to aid measurement of power consumption; measuring conductivity of water from salt water to fresh water. Level of salt extraction should cause the water to be compatible for human consumption. Measurement used to assess the performances of the machines. Measurement used to assess the profitability of the diesel fuel being used in the conversion of diesel to Electrical energy. Measurement used to measure the capacity of manufactured water to be classified as a profitable commodity.
Branch of mathematics involved in activities of the osmosis plant	Functions and graphs: used to record readings of temperature at different occasions**;** statistical averages: mean, mode, and consumer arithmetic, specifically calculation and arithmetical operation on numbers, profit, loss percentages. Understanding the place values of number. Measurement
Objectives	My examination of the objectives informing the mathematics content for the specific branch of mathematics indicated that the newly employed would have been exposed to the following mathematics content and therefore should have been able to: Demonstrate an understanding of place value

	Demonstrate computational skills Appreciate the need for numeracy in everyday life. Hence students should have been able to: Perform computation using any of the four basic operations with real numbers to include, multiplication, division, addition, and subtraction. Convert from one set of unit to another. Convert any fraction to percentages. Calculate discount, profit or loss.

Comment

While in school, algorithms were required for each mathematical problem, in the work place employees were merely required to operate a switch, bearing the words "on and off". The mathematical algorithms were located in built in software in the technological knowledge informing the plants' operation. However it was a requirement for the employees to be in possession of knowledge associated with each mathematical principle. This could then be employed in moments of break downs. My observation of how the routine for the jobs were performed led me to conclude that at this plant the newly employed would have been able to handle the mathematics required in this work despite they themselves not being in possession of the mathematical knowledge. The mathematical component would have been reduced to an activity, controlled by a switch entailing an up and a down move

I am unable to state conclusively whether or not the newly employed would have been in possession of adequate mathematical knowledge to have allowed him/her to offer substantial mathematical information to resolve a pending break down in the operation of the plant. Indeed, even as the teacher of such students, one would/could never really suggest how much of what mathematics objectives had been taught were understood or learned by students. Hence my suggestions would be inconclusive. In fact:

> *At the osmosis plant the mathematics was embedded in the activity of the plant, which occurred when the plant was required to pump water around to the homes on the island. Measurement of the water made from the reversal osmosis plant. One had to monitor all the water made; monitor power consumption*

taken to make the water. This could fluctuate as some of the operative parameters changed. However, if there were no monitoring, there could be wastage of electricity while processing the water. This activity was also the same for the generators. If there were no monitoring and measuring then there could be wastage of diesel fuel instead of the conversion into electrical energy (Manager).

The other mathematics would be to calculate? All the water pumped around the island in its various forms has to be measured and balanced at the end of the month. How much they have made; how much they had sold. Hence, reading of metres and calculation of figures was the basic subtraction – finding differences and then doing the calculation on the figures after.

Recovery of water from the sewage station once it comes back is treated and recycled. This has to be measured. Mathematics occurred where the activity was making fresh water from sea water**.** Here chemicals used were of a variety some were dangerous hence there was need for exact measurement; measure the conductivity of the water to see that there was no salt in it. These are the mathematics in work.

More mathematics was engaged in the control room while conductivity process was in operation. At this worksite there were four generators involved. Since in recent times there was an increase in demand for utility services whereas before there was one electrical line taking electricity to consumers the tool known has the *Lobe* had been divided into two halves to ensure that capacity met this increase in customer's demand**.** Hence the mathematics occurred from measuring the activities in the generators;

In generator 1**,** this measurement entailed what power in kilowatt hours was being produced; measuring the hours the machine has been in use over its life time; measuring the battery voltage and measurement of the frequency voltage in amperes. By deductions from these figures the information as to the type of servicing was required by the engine was obtained. Indication would have been given for the type of treatment that was required: when to change the oil when to service the plant and the specific treatment required.

From the *generator 2*, the measurement would have provided information for hours done, temperature, battery voltage, frequency voltage and how many times the engine had started. Minimum and maximum figures were also obtained every twenty four hours to see exactly what was going on in the system. The measurement and calculation from these figures guided this operation. There was also a daily inventory. From this graphs were plotted. The graphs were used to predict future projection of growth in the business

There could be even more complex calculations involved since an increase in load would have caused two generators to run at the same time. There was again a technological tool controlling the mathematical operations. The calculation was just taken for granted since they were located in Black boxes (Williams and Wake, 2007). Noise of the engine room was controlled by use of fibreglass. However all decisions, checking and monitoring of activities in this site were based on mathematical principles. I concur with the manager's view, that mathematics kept the plant running while forming the foundation for all decisions taken in relation to servicing and care for the plants.

School leavers entering directly into the workplace would therefore be required to learn the procedure for monitoring and measuring the appropriate activities of the plant. They would also be called upon to know how to operate the mechanisms that allow the engines to functions – here it was controlled by a switch which turns on generator at 480, and went around the island at 7,200 volt. Here a complex operation was engaging simple actions from employees. Using of results was all that was required in this workplace mathematics. Measurement was the skill required. Operation of generators was governed by turning on a switch. An achievable task for all school leavers however questionable was their concentrative power and the ability to read and record the correct figures from the meters due to this alluded to lapse in concentration. Performing the correct calculation to achieve right deductions was quintessential in this mission. In the **Table 7.8,** I present findings from the garage.

Garage

Table 7.8: Findings from the Garage's Data

Categories	**Worksite - the Garage**
Tool	Lathe machine, mechanical parts for engines and mechanical equipment and vehicle
Operations of employees	Measurement to ensure correct and specific size of parts needed for the fittings on vehicles. Conversion in metric millimeter and imperial measurement Knowledge of concept of equal capacity and volume as it relates to fill and removing fuel from a vehicle's engine. Lack of this knowledge could cause damage to the engine.
Branches of mathematics	Measurement and computation
Objectives from school's Secondary mathematics curriculum	Having completed mathematics course in school, the newly employed should have been aware of the importance of accuracy in computation. (CXC05/G/syll08, pp.17-18)

Comments

Mathematics at the worksite was different in format from classroom mathematics. Mathematics was an *activity*. It was an invisible utilitarian tool used by employees without being conscious of its mathematical parameters. Hence at the garage employees were surprised that I was asking for an identification of mathematics in work! Mathematics was something done in school. What they were doing at the work site in their view was just being engaged in an activity associated with their work, but not mathematics! However that activity was founded upon mathematical principles.

The activity in the garage involved repairing and replacing of vehicular parts and changing of oil in the engines of the vehicles. As mentioned the branch of mathematics was measurement: as it related to various sizes when parts for replacement was the focus and measurement to indicate capacity where changing and replacement of engine’s oil were the activities. It was important that correct measurements on all occasions informed employees’ work. There was always a consequence for one’s actions which could be advantageous to the business or with a negative impact causing a disadvantage to the business.

Thus employers were called upon during the process of their work to make judgements to act responsively since each individual was responsible for his own actions. This demanded attention at all times during the fulfilment of daily routines. In brief, for any one activity addressed by employees all the sensory organs was engaged. There was a holistic approach to all activities. Generally activities were performed from a standing or crouching position hence fitness of the body to take this strain was an important physical requirement. Activities were seemingly carried out with co-operation of fellow employees.

Yet during all of this activity, the employees were never conscious of the mathematics involved in their work. Calling upon employees to be responsible for actions was not something that was associated with classroom mathematics. Each person was asked as a unit, to address the assigned exercise on his/her own. Team work was not encouraged. Yet at the workplace, team work was an important backup mechanism, since there was seldom room for error, since it impacted negatively upon the business’ profit margin. Hence correct actions were a key element associated with workplace mathematics in the garage and by extension the parts department of the maintenance division in the hotels.

Table 7.9: Findings from the Laundry Department

Categories	Findings from the Laundry Department
Tools	Scales, washing machines, Ironing machines, detergents, water, electricity, charts, and work's roster-manning.
Operation	Weighing of all materials to be laundered; correct choice of appropriate washing machine in terms of size: compatibility of temperature where laundering different texture of material; Correct volume of water to ensure cleaning of mechanisms used in machine's operations. Calculating timetable for employees, supplying information for number of employees required to fill vacancies/positions in the offices, the rest rooms, the restaurant and the public areas. Here calculations would be based on rate of occupancy.
Branches of mathematics associated with operations	Measurement, set theory, logical reasoning, combination, permutation and consumer arithmetic (CXC/05/G/Syll08, pp.17)
Objectives from school's secondary mathematics curriculum	In accordance with the school's mathematics curriculum, the newly employed should be able to: Demonstrate the ability to communicate using set language and concepts; Demonstrate the ability to reason logically; Appreciate the importance and utility of sets in analyzing and solving real-world problems.

Comment

Though specific objectives would have been taught, the lack of a practical component to the mathematics syllabus, lack of linkage between taught mathematical lessons and their affiliation to workplace activities, could have made it not readily perceived by students of the association to workplace activities. When this is measured against the perception of most Antigua and Barbuda students of mathematics being conceived as classroom work for assisting them to gain qualification for the matriculation/certification for higher tertiary education or for qualification, I would argue that since the utilitarian aspect of mathematics was not seemingly part of school's mathematics education, I could not be sure that the association that was needed to be made between the mathematics in this work, was recognised by the employees. Therefore handling of any mathematics in this area would have been from customary practices in the area. In fact on my arrival at this department and asking for the mathematics in this work, employees were not aware of the presence of mathematics in their work.

Table 7.10: Findings from the Construction Site

Categories	**Findings from the Construction Site**
Tools	Bucket, water, sand, stones/aggregates, cement, area to be fenced, String, Tape measure, construction tools, and mathematical calculators.
Operations	Calculate the number of blocks needed to build a wall of length "a" ft. and height,"b" ft. Knowledge of correct strength of mortar to ensure durability of the wall. Hence importance of understanding the ratios: 1:2:3 and 2:4:6
Branches of mathematics	Areas, perimeter, and ratio.
Objectives from school's mathematics,	Having being taught from the school's secondary mathematics curriculum the newly employed should have been able to compare two or more quantities using ratios; divide a quantity into a given ratio and to handle the computations involved in any calculation required (CXC 05/GSyll08 p.12).

Comment

While ratio is taught in the classroom because there is hardly any connection with the real world experience, I could not conclude with certainty that the mathematics use at this site was transferred from school mathematics content. Most of the mathematics taught in school is linked and associated with the number theory component with no link to the real world or activities in the workplace. The mathematics involved at this site was more from intuitive knowledge and modelling. Therefore the newly employed would have been able to learn the trick in the trade of real work application because of collaboration that takes place in activities of this nature in the workplace. Absence of the practical component to the mathematics curriculum would cause me to conclude that the secondary school mathematics curriculum had not appropriately prepared school leavers for the workplace.

7.9 Mathematics Associated with Technological Tools

In this section I examine the mathematics involved with the operation of tools used at the worksites in Antigua and Barbuda. The technological era has made it mandatory for works to have skills in operation of these tools. Some of these skills are founded upon mathematical principles. What are these principles and the nature of the mathematics associated with these tools form the core of our discussion and analysis in this section.

7.9.1 Mathematics and Black Boxes

Like Nicols (2002), Williams and Wake (2007, p.320):

> *Noted how workers, students and even teachers found difficulty in identifying mathematics in workplaces. They reported of some research having concluded that workplaces demand minimal mathematics (Riall & Burghes, 2000) while others say rather that significant mathematical demands arise during particular 'breakdown' moments when routines are challenged by new or unusual situations (Pozzi et al., 1998), or that mathematics may be difficult to recognise because it is bound up or hidden in black boxes by technology (Hall et al., 2002 cited in Williams and Wake, 2007, p.320). Williams and Wake (2007) have claimed that some in mathematics education have used the term black box for the result of this technological process, and have sought to clarify how technology can also serve as a means to illuminate what is hidden in these black boxes.*

Furthermore, 'Straesser (2000) suggested that hiding mathematics in black boxes signals an increasingly mathematical social life, (because of more people being more likely to engage in mathematics embedded in the technological tools informing workplace activities. Previously all mathematics was learned in classroom, with people having a fear and refusing to have dealings with anything with a mathematics component base). This is also taking place even in situations where workers and professionals continue to report that mathematics is progressively becoming invisible, 'disappearing' from the workplace' (Williams and Wake, 2007, p.320). Straesser (2000) gained support from Williams and Wake (2007, p.320) in making the assertion that 'this contradiction is at the heart of the problem for vocational mathematics education'. It is the belief of

Williams and Wake (2007, p.320) that the value of their research will come from the ability of 'their theoretical work building on and adding to these concepts of break down and black box: in particular their ability to show two processes by which black boxes are formed and how these processes shape as well as hide the mathematics involved in distinct ways'.

However, Latour's (1987, pp. 2-3) notion is broader than boxes which include machines, but also ideas and concepts and 'scientific facts. Williams and Wake (2007, p.321) claim that 'the term black box used in workplace literature debate is borrowed from the discipline of cybernetics where the meaning parallels the function served here. The term is used 'whenever a piece of machinery or a set of commands is too complex. In its place they draw a little black box about which they need to know nothing: he notes the role of objects, people and ideas in networks that can become black boxed. Thus he describes the Kodak camera as 'a distributed complex 'network' of actants - persons, materials and organisations - without which the machine would not function.

For Latour (1987, pp.2-3), this network becomes a black box for the user, because 'it acts as one piece' and he says 'when many elements are made to act as one that is what I will now call a black box'. Later Latour (1999, p.304) defined black-boxing as referring to:

> *The way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one needs to focus only on its inputs and outputs and not on its internal complexity. Thus paradoxically, the more science and technology succeed the more opaque and obscure they become that mathematics is progressively becoming invisible, 'disappearing' from the workplace.*

As the mathematic officer leading the nation's mathematics education policies, my suggestion to policy makers and designers of mathematics curriculum, would be one of ensuring that a subtopic to discuss the role of black boxes form part of the content of the mathematics syllabus. This content could commence by way of a definition. For as cited by Latour (1999) and to be found elsewhere in the work of other scholars, the term black box could conjure several meanings to different people (Hall et. all 2002, Williams and Wake, 2007).

For example, from the Antigua and Barbuda perspective the term would be used to describe any device which hides the algorithm to a mathematical problem, so that the user is only required to know the ‘input and the output’; while at the same time accomplishing complex mathematical problems using a switch with the words ’on’ and ‘off’ as a part of the device being used to accomplish the task. I would argue that black boxes of themselves do not require teachers to change teaching methods or strategies employed to teach any mathematical concept. On the contrary, they make the case for teachers to ensure that students are cognisant of their presence and the importance of this role.

Indeed one of the major factors communicated to learners and users of technology from scholars in the field (Nicol, 2011) is that the success of any technological operation is dependent upon three elements: (I) a building to house the technological devices (ii) the technological devices and (iii) a human being with the knowledge of how to operate the device (Nicol, 2011). Of these three elements human beings were quintessential to the success, since technology and a building on their own could not achieve the desired outcome without the human mind.

Therefore, black boxes which are generally linked to the operations of technological tools, necessitate the need for teachers to be trained and empowered with the skills, with the knowledge and the literature of black boxes where the focus is on using these technological devices to find solutions to given problems. On the other hand, the teachers’ task of teaching students the appropriate algorithm to mathematical problems, thus making them experts in the field, making them experts in logical reasoning and making them experts in arriving at appropriate decisions to problems, have not been rendered ineffective by the presence of black boxes in the labour market. Rather, the need is for teachers to ensure that in their mathematics classrooms, explanation for taught mathematical concepts remains the bread and butter of all classroom mathematics lessons (Thames, 2006).

The necessity arises where employees using technological tools to solve mathematical problems, could be required in break down moments to be in possession of knowledge that could be readily communicated to other workers, located at a different worksite (Thames, 2006). Hence students should not only be schooled in mathematical, algorithmic, procedural measures, in working problems to gain a passing grade in a classroom mathematics test, but teachers should be engaged as well in ensuring that both procedural matters and the utilitarian aspect of taught mathematical concepts, are communicated to them.

This in my view should be a part of the Antiguan and Barbudan classroom environment for mathematics lessons in this 21st Century and beyond. Additionally since black boxes will be a part of the operations of daily routines at worksites where technological devices constitute part of the tools for the labour force, it is necessary for the literature to be a topic in the mathematics syllabus. I support Straesser (2000) in believing that 'hiding mathematics in black boxes does indeed increase the social life of mathematics, making it accessible to a larger number of individuals who generally would not have been able to solve a mathematics problem.

Therefore, black boxes could narrow the gap between the number of persons who would not have been able to handle a problem based on mathematical formulae and those who would have used mathematical principles to accomplish the task. Black boxes could allow more people to use complex mathematics algorithms albeit hidden in black boxes to solve mathematical problems. In this manner black boxes could serve in narrowing the gap between:

- the Non mathematicians and the mathematicians
- Number of persons using mathematics to solve real world problems and those who do not.

In the next section I examine cases where precision in using mathematics in real world activities is required.

7.10 Mathematics where Precision is Required

In this section, I locate areas in the workplace where precision and accuracy are the skills required by employees while using functional mathematics in their daily routine. In the paragraph below, I name activities where the mission occurs, together with the tools used to accomplish each mission. Additionally, I locate the area in the mathematics syllabus where students would have been taught mathematics content to accommodate this requirement. Finally, I offer suggestion as to whether students would have been appropriately prepared to handle this type of mathematics in the workplace.

The activities concerned with precision in mathematics, generally involved measurement in different forms. Several of these different forms and their tools provided content for this section of the analysis.

- The micrometre was used for reading the measurement for the threads on bars of parts made by the lathe, once the correct thread required was identified using charts associated with this task. Using the digital precision readings eliminated any guessing associated with required figure for size of part being constructed.
- In horticultural work associated with the gardener in administering treatment for plants, blending of the different chemicals in the correct proportions was important for avoidance of burning of plants. The mixture cannot be too strong or too weak. Precision was required. Also, mixing and blending of pesticides required the same precision.
- Different chemicals for treatment of waters also had to be done with precision. Some are dangerous. Therefore, in performing conductivity of water, thereby ensuring no salt was in the water, required precision in proportions, of the different chemicals involved in work.

- Precision was required for measuring voltage, ampere, frequency in hertz and the power it was producing in kilowatts. Lack of precise measurement could have damaged engines or could have caused wastage of diesel fuel.
- Precision was required in the work of the mechanic in terms of making sure in replacement or in construction of engine parts, the task of providing the size, which was an exact fit for purpose was achieved. Also, in changing of engine oil the removal and subsequent replacement of volume of oil should be identical. If 'it was too little, a problem; too much still a problem' (Mechanic, 2009). Hence precision was required.
- Whereas for the general chef, there could be some estimation in work, the entire task associated with the *pastry chef* required precision in measurement. Hence all activities had to be performed with the aid of a measurement tool. Precision was required.

Other areas where precision was required included:

- Correct change for bills paid to receptionists
- Correct compass bearing when steering the ferry
- Correct time in changing over of equipment associated with running of generators
- Using techno mathematical tools of *jigger and ounce pourer* to ensure precise measurement and to avoid wastage
- Training of workers - *mixcology* – required employees to use precise amount of ingredients when mixing and when blending drinks.

This was not an exhausted list. Hence in different areas and for different reasons precision was important. Lack of precision generally impacted negatively on operations in the worksite. In some areas it could be fatal. Impacting negatively, incurring damages to the tool, wastage and loss in revenue to the business enterprise were additional consequences.

Using the schools' secondary mathematics curriculum the following categories and objectives would have been instrumental in laying the foundation to employees' knowledge base for the required mathematics. These suggestions now form the content of **Table 7.11**..

Table 7.11: Categories of Mathematics Associated with Precision in Using Mathematics

Categories	**Objectives/students should be able to:**	**Content**
Computation	1. Perform computation accurately using any of the four basic 2. Convert from one set of units to another 3. Compare two quantities using ratios 4. Divide a quantity in a given ratio.	1. Addition, Multiplication, subtraction and division of whole numbers, fractions and decimals. 2. Conversion using conversion scales, converting with the metric scale, currency conversion. 3.Ratio and proportion 4.Ratio and proportion
Consumer Arithmetic	1.Appreciate the need for both accuracy and speed in calculations 2. Demonstrate the ability to use concepts in consumer arithmetic to describe, model and solve real-world problems (G/objective)	None suggested None suggested Content showed a heavy bias to business transactions
Measurement	Appreciate that all measurements are approximate and that the relative accuracy of a measurement is dependent on the measuring instrument and the measuring process Demonstrate the ability to use concepts in	

	measurement to model and solve real-world problems. Calculate the volume of solids	
Sets	Demonstrate the ability to reason logically (G/objective)	None

Precision in mathematics is taught in the mathematics classroom only in specific dimension of measurements given to students in areas of geometric construction. Additionally in computation students are advised and implicitly taught the value of being accurate in their calculation. However the whole notion of precision in its subjective dimension which would have been derived from logic and reasoning is not a part of the mathematics classroom. In fact the whole category of reasoning and logic was dropped from the syllabus since some teachers' experienced great difficulty in teaching it. Therefore it would have been left to other subject disciplines to include Technical drawing, wood building, construction and home economics, where precision and accuracy were the hall mark of all activities, for students to develop perception of what precision entailed. For students not having such practical subjects as one of their discipline, it would have been left to on-the-job training. One participant (Food and Beverage manager, 2009) cited the use of mixcology test to achieve this very skill, where employees were tested in the ability of precision every two weeks, to perfect and maintain the standard in daily activity ranging from ingredients for a gin and tonic, rum and coke, rum punch or any other drink.

Too much of the objectives associated with precision were number based operations. Therefore with the practical aspect of the mathematics syllabus not a part of the curriculum, I can only conclude that from classroom mathematics lessons students would not have been appropriately prepared to handle immediately the concept of precision required in some work activities. The gap could have been narrowed at the workplace where technological tools to include the jiggler, the ounce pourer and the lathe were tools informing work. Since most of the specific objectives for the mathematics lessons are based on numbers, it is very difficult to measure how much of school mathematics lessons could be readily transferred by newly employed into their workplace as tools.

This demonstrates the need for the practical part of the mathematics syllabus to become part of the mathematics lessons in school. Hence at the moment where only procedural aspect of the proficiency of mathematics is informing classroom lessons, students are inappropriately prepared for mathematics activities in workplaces. In the future designers of mathematics curriculum should ensure that the practical and the utilitarian components are part of the content material. No appropriate preparation of students for the workplace could have been achieved with these omissions. Because most of the technological tools were working from operations of a switch to include a vertical or horizontal movement, the black boxes hiding the mathematical equations and operations involved while using these tools, served a prominent role in narrowing this gap of none possession of skills for precision and the requirement for the skill by employees to inform work.

However training employees to use some of the complicated technological tools could be costly to a business enterprise. Therefore, the need for students to know the procedure for the embedded complicated mathematics operations, would make it mandatory for schools to ensure that there was a connection between the mathematics required at each workplace in the Antiguan and Barbudan society (our microcosm of global requirement since economy is informed by direct foreign investment) and the mathematics curriculum’s content informing classroom lessons: especially now that on-the-job training will be a thing of the past (World Bank researchers, 2007).

7.11 Mathematics in Three Dimensional Formats

In this section I highlight the presence and the use of three-dimension mathematics in the workplace. I begin with suggestions as to possible causes of origin of the difficulties students experience while being taught this aspect of the mathematics syllabus. I then examine the importance of geometry to students in everyday life. This examination is based on the fact that geometry is the foundation underpinning most of the three-dimension mathematics found in the workplace. Following this, I then locate the specific areas in the classroom's mathematics syllabus informing three-dimension mathematics objectives and content. Subsequently, I offer suggestions as to whether or not the three-dimension content informing classroom lessons is appropriately preparing school leavers for the workplace. The suggestions are based on my identification of areas in the workplace where three-dimension mathematics is informing the daily routines of the newly employed. Findings from my field work are presented before my suggestions for future work with three-dimension mathematics.

In the Antigua and Barbuda mathematics classroom, the three-dimension mathematics in the school's curriculum presents most students with some degree of difficulty and anxiety. These occurred at moments where students were called upon to use the three-dimension mathematics information to solve theoretical problems. Some teachers, especially the female teachers of mathematics, are not comfortable in teaching the topics comprising this section of the syllabus. This difficulty experienced by both teachers and students could be linked historically to the fact that teachers, who are now teaching mathematics in the secondary school division, would have themselves being informed by a curriculum, built on the behaviourist principles. This behaviourist mode was heavily characterized by its notion of learners, in formal setting, learning mathematical concepts using rote. Having examined and having analysed the content of three-dimension mathematics topics, I would argue that the three-dimension aspect of mathematics is founded upon a constructionist mode of inquiry, since a picture at times could easily convey the information that was being communicated to the learners. Where lessons were not using the constructionist trajectory, there could have been difficulty for the learner in understanding the taught mathematical concept.

In fact, the history of education and its origin in Antigua and Barbuda, would reveal that prior to gaining its independence in 1981, the primary school's curriculum was limited to the three ‘Rs’: Reading, (w) Riting and (a) Arithmetic (see Chapter 2). In the monoculture economy which was based on sugar, the mathematics required to inform work was located in the discipline of Book keeping. This came with a heavy arithmetical bias. Hence the arithmetic informing primary education was sufficient for what was required. In this era, the masses were only required to work in the cane fields as labourers, where the strength of the individual, the physical stamina to work in tropical conditions (sun, 85F) and muscles were important. Counting of rows and weighing of tonnage of canes were the only mathematics involved here.

Since ‘art’ was not a subject on the school’s time table, spatial development for many students went untapped. Later when ‘art’ was partially introduced into primary curriculum, it came with a bias: only the male students were allowed to engage in this activity, since this was performed simultaneously as the time of sewing lessons for the female students. Blame could be apportioned to this practice for the inability of some female students to think or to visualize the world in a three dimensional configuration.

This inability of some female students to think in a three-dimension mode could have been exacerbated from the fact that geometry was not a part of the school’s mathematics content. The importance of geometry could be cited thus:

- *First, the world is built of shape and space and geometry is its mathematics.*
- *Second, informal geometry is good preparation. Students [could] have trouble with abstraction if they lack sufficient experience with more concrete materials and activities.*
- *Third, geometry has more application than just within the field itself. Often students can solve problems from the fields more easily when they represent the problems geometrically.*
- *Fourth, many people think well visually. Geometry [could] be a doorway to their success in mathematics.* (National Research Council Workshop, 1998, www.curriculumsupporteducationstn.gov.ausecondary/mathematics/crosscurriculum/vocational/voced.hm)

Three-dimension mathematics is heavily dependent upon students being in possession of a knowledge base with some of these listed properties of geometrical factors. However, because mathematics was not readily perceived by employers as part of work, the general mathematics skills required by workers for the three dimensional mathematics in their workplaces, were not readily signposted by them in work. As it pertained to the status of the new employees' background in mathematics, from my field visits to workplaces and my conversation with some employers, seemingly the importance was only extended to the level of proficiency pass candidates had acquired in the annual school leaving CXC mathematics CSEC results. In fact:

> *The Basic Proficiency was originally mandated to prepare students for the world of work. But employers were adamant that the General Proficiency level was what they were accepting. Therefore the world of work was demanding more mathematics knowledge, than what the Caribbean Examination Board setting syllabi thought was necessary. So that, although the Basic Proficiency was sufficient for workplace operations, the more demanding and academically geared General proficiency content was the preferred choice* (Athena).

This choice was not based on appropriateness for the workplace, but rather on the status of students. In Antigua and Barbuda there was a perception that the basic proficiency was for the 'dunce' students. There were only one human resource personnel in the hotel industry that cited the academic value as the main reason for his/her choice of the General proficiency level for a passing grade. In his view, this was to:

> *Accommodate mandatory on-the job training of newly employed seeking a career in the hotel industry. In this training mathematics is a real problem. There needs to be a stronger foundation base for employees from school mathematics lessons in the areas of: basic fractions, knowing multiplication tables, simple conversion, three dimensional mathematics problems, and division. This foundation knowledge is needed to perform the role of a spring board for higher academic on-the-job training in hotel courses. Where this foundation is lacking it usually takes six months to a year for employees to attain required standard. This is a gap that needs closing during classroom mathematics lessons, while preparing students for the world of work.*
>
> *If one is to produce quality service in this competitive industry, employees should be exposed to certain type of knowledge to ascertain reasons for the*

need to keep on top of the knowledge pervading the hotel industry. Application of knowledge of mathematics is important for workplace routines for several reasons. First, when the principle of division is not understood by kitchen workers there is wastage in the preparation of meals. Second where the dynamics of ratio is not understood, a cost is incurred. No business can be profitable where employees are lacking in basic mathematical knowledge. Until the balance and gap can be closed in deficiencies of mathematical knowledge by the newly employed, there will be a lost in profit for the enterprise. No business manager would be willing to employ or to continue on-the-job training in a climate where the economy is presently knowledge based.

To address the problem there needs to be a separation of book knowledge from real world application of mathematical knowledge to problems. In the classroom this could take the form of assignments involving mathematical projects. Outside the classroom this could involve mathematical visits to worksites to examine the mathematics in work (Human Resource officer).

Three-dimension mathematics plays a paramount role in all sectors of the labour market. It is to be found at the construction site, where length, breadth and height of a wall under construction was the work involving mathematics; in the garage where making of different mechanic parts was the operation; at the osmosis plant, especially in relation to circular cylinder containers, housing manufactured pure water, to name a few areas. An examination of the CXC's secondary school mathematics curriculum informing classroom mathematics lessons reveals that three-dimension mathematics is taught in classroom mathematics lessons, to accomplish the following objectives, using specific content. This information now forms the text of **Table 7.12**.and **Table 7.13**

Table 7.12: Showing Location of Three-Dimension Mathematics in Secondary School's Curriculum

Category	Objectives	Context
Measurement	*Calculate the surface area of solids.*	Prism, cylinder, Cone, sphere, cube, and cuboids
Measurement	*Calculate the volume of solids*	Prism, pyramids and all of the above.
Geometry	Solve geometric problems using properties of circles and circle theorems	The angle which an arc of a circle subtends at the center of a circle is twice the angle it subtends at any point on the remaining part of the circumference. The angle in a semicircle is a right angle. Angles in the same segment of a circle and subtended by the same arc are equal. The opposite angles of a cyclic quadrilateral are supplementary The exterior angle of a cyclic quadrilateral is equal to the interior opposite angle A tangent of a circle is perpendicular to the radius of that circle at the point of contact. The lengths of two tangents from an external point to the point of contact on the circle are equal.

Table 7.13: Showing Location of Three-Dimension Mathematics in Secondary School's Curriculum

Categories	Objectives	Context
Geometry	Appreciate the notion of space as a set of points with subsets of that set (space) having properties related to other mathematical systems. Understand the properties and relationship among geometrical objects. Demonstrate the ability to use geometrical concepts to model and solve real world problems (General objects). Solve geometrical problems using properties of congruent triangles, similar figures, faces, edges, vertices of solids and categories of solids	Cylinder, spheres, prisms, pyramids and cones
Trigonometry	Use trigonometric ratios to solve problems in the physical world. Solve practical problems involving heights and distances in three dimensional	Heights and distances, Angles of elevation and depression. Source: CXC, 2012 05/G/syll 08, p.30

Distinct from the mathematical procedures and mathematical information hidden in black boxes, the newly employed is mandated to know and to have a mental picture of all the mathematical operations hidden in these black boxes. S/he is also expected to know the algorithm informing whatever mathematical operation is required to accomplish tasks in their workplaces. This is claimed to be required at break down moments in the enterprise's operation so that the location, the nature and the extent of the problem could be ascertain by all workers, even those working in another country. This is to facilitate a quick resolution to the existing problem (Hoyle et al., 2010).

At school, in addition to lessons focusing on three-dimension mathematics, students are also engaged with an application of three-dimension mathematics in disciplines to include: technical drawing, construction, wood work, chemistry, physics, art and craft, art, home management and information technology. The specific area in terms of technical drawing is isometric and orthographic drawings. In fact specific aspect of the content for this area of the technical drawing syllabus now forms text in many mathematics text books (See Greer and Layne, 1994, pp.128-137). On the other hand in the world of work, students could have handled the mathematics in work due to the role team work plays in this system. Simulation, modelling collaboration, the technological tools and on-the-job training could have increased the chances of the newly employed being able to handle the three-dimension mathematics in their daily routine in the workplace.

However, in the mathematics classroom lessons, teachers need to exhibit more confidence in teaching of the content in this area of the syllabus. This could be made possible by using projects as the practical component to the mathematics syllabus. As the mathematics officer in charge of mathematics matters, I should now be seeking to introduce the practical component to the entire mathematics discipline to ensure that it forms part of all mathematics lessons. In the lower forms in secondary schools CXC has already introduced a practical component. However, teachers' perception of its value does not extend beyond the requirement for examination. In future curriculum designs the practical component should be a fixture. The time has come to strengthen the relationship and to close the gap between the tenets of classroom mathematics and those of workplace mathematics.

Nevertheless, despite known difficulties that are present in the mathematics classroom, for the topic related to three dimension problems, students experience no such difficulty when asked to use or to apply principles of three dimension mathematics in art, art and craft, home management and vocational disciplines. This was borne out from my observation in the craft market where most of the products on sale were exhibiting the presence of three-dimension mathematics in work. This was the mathematics involved with activities in the craft market, where design of direct ornaments for souvenirs and clothing were being made. Designing was the focus of the activity and geometrical shapes was the branch of mathematics involve.

Also in the garage and at the osmosis plant where storage of fresh water made from sea water was stored volume came into the activity. The three-dimension mathematics in the work place was from the branches of mathematics ranging from trigonometry to differential calculus. However the algorithms were usually located in black boxes. School leavers were only demanded to use the results

Workers were not demanded to learn in any formal pattern the mathematical operations governing their work. These for most of the worksites were functions assigned to technological tools with workers, although require knowing the operations embedded in the tool were generally only required using the results. There was hardly any clear cut identification by employers of the mathematical requirement of workers. For them this mathematics requirement was part of the environment and the context in which the mission was being performed. This could be learned in context. Therefore the philosophy of hiring the personality and train the skill was predominant in most work places. The information in the table would support this view, where instead of getting mathematics required in work it was generally the characteristics that was required by the individual in terms of personality to be a fit for employability chances.

In conclusion I argue that for most employers in Antigua and Barbuda, newly employees' ontological characteristics are valued more highly than their mathematical competencies. This overrides alternative decisions when an employer is about to hire a new employee. In fact employers express great satisfaction with the knowledge that new employees have the capacity to be trained in workplace procedural matters, which included handling and applying the requisite mathematics content on the job. Hence the slogan resonated by most employers when applying their philosophy for the newly employed: 'hire the personality and train the skill' (Antiguan and Barbudan employers). It is further my argument that although the three–dimension mathematics lessons taught in secondary school are not appropriately preparing school leavers for the workplace, reasons advanced in Chapter 6, new employees are able to handle the three-dimension mathematics in the workplace.

7.12 Mathematical Needs of Workers in Antigua and Barbuda

In this section I examine the mathematical needs of workers in Antigua and Barbuda. I begin by way of a statement, focusing on the role of mathematics in the workplace of Antigua and Barbuda. This is followed by the introduction of a poem in which I outline what are the mathematical needs of Antiguans and Barbudans. Finally I reflect on the approach that I should be adopting to take the process forward to change how mathematics is taught in classrooms of Antigua and Barbuda.

Only once was mathematics the focus of the needs for the newly employed: in that situation the employer was asking for the mathematics from school knowledge to act as a foundation for the more advance appropriate knowledge that was associated with the tourism industry. In the workplace, mathematics was a tool and was of value only for its utilitarian value. Hence it was located in black boxes in the techno mathematical tools associated with the employees' routines. The mathematics used in these workplaces was viewed as activities and could be learned from the tools or from daily repetition of the same activities.

Although I am still on the battle field enough structures are now in place to cause a result beyond mere sensitization of the public to the value of mathematics in the job-market. Some of the innovations created as the revolution in teaching and learning of mathematics in the Antiguan and Barbudan mathematics classrooms could be sourced at the following sites:

htpp://www.youtube.com/masteringmathematics;facebook.com/masteringmathematics; www.caribbeanoer.org; www.masteringmathematics.info

The mission has now expanded to include the reformation of the education process in the Caribbean (UWI, School of Education, Cave Hill, Barbados). Antigua and Barbuda could be used as a model. However the revolution in mathematics education in the twin island state of Antigua and Barbuda has begun.

Impact of Employers Mathematical Needs on Mathematics Education in Schools

Impact of Employers' Needs on Classroom Mathematics

In this section, I offer suggestion on the impact of employers' mathematical needs on classroom mathematics lessons. These suggestions were listed randomly. Suggestions emerging from the analysis of the data indicated that training of teachers in mathematical content, visits to workplaces and the training of employees in mathematical algorithm hidden behind computer screens or embedded in technological tools used in workplaces provided content that highlighted the need for changes in classroom mathematics lessons.

One of the roles of the Ministry of Education in the Antiguan and Barbuda's society is that of training individuals in social skills, to promote socio economic development and to make sure each citizen develops to full potential (Education Act, 2008). Since the Antigua and Barbuda government believes that the development of human resources is the key to national development, I would expect that educational opportunities would help to develop students' knowledge, skills, aptitude and appropriate attitudes that would make them productive members within their societies (Crump). However, with mathematical techno-mathematics literacies informing operations in workplaces and with employers demanding more highly skilled workers, there is the need to examine the impact of employers' demands on classroom mathematics.

Despite achieving its independence, (01 November 1981) the education process in Antigua and Barbuda is underpinned by a philosophy informed by tenets of a seventeenth century industrial era based on the Westminster Industrial Education era. Therefore, in an era where knowledge is the unit of production, demands of employers have impacted the way in which classroom mathematics lessons are taught and learned. In fact according to the Minister of Education (2007):

> *There is the need to enact certain changes in education. For example, ensure teachers are appropriately resourced to enter classroom to cope with the job. Hence the time has come to make the change from the blackboard to the white board, additionally; there is the question of usage of technology in the mathematics classroom.*

Also emerging from the data are suggestions for us as educators to address the following concepts:

- Authentic (real life) learning
- Change in methodologies and strategies used to teach mathematics
- Labour market demands
- National, regional, and global concerns
- Meeting the needs of individual students

In this thesis and in this section, I addressed only the impact of the labour market demands, since it parallels the impact of employers' demand, which has impacted classroom mathematics. Over the years, the mathematical needs of employers have resulted in several changes in our mathematics education program. These changes could be stated thus:

- From a two tier proficiency level of mathematics syllabi: Basic Proficiency and General Proficiency, due to the demands from employers for the general proficiency level to be used for qualification of entry into the workforce, only a one tier proficiency level now informs mathematics education in our schools. However, while the general proficiency is more academically inclined, employers have demanded this level over the basic proficiency level. Yet, it was the basic proficiency level which was designed to prepare students for the world of work. This is a contradiction, since the general proficiency level is geared for students pursuing the tertiary trajectory. But due to employers' demands, the tertiary level syllabus, general proficiency is now informing preparation of students for the workplace. Subsequently, since the basic proficiency syllabus was no longer economically profitable to administer, the Caribbean Examination Council, as the official examination agent has withdrawn it from the school's curriculum

- The highly technological skills required for work place operations by employees, have rendered low-skilled employees inefficient for the present high skilled technological based industries informing workplace operations. In order to ensure preparation of students to meet these conditions in the workplace, mathematics teachers have had to ensure that technological competences are part of the classroom's mathematics lessons. Not only has the ministry had to ensure that teachers possessed the relevant mathematical knowledge base to teach classroom mathematics, it has also had to change its recruitment practices for mathematics teachers. Presently, to be employed as classroom mathematics teachers, prospective candidates are required to pursue training in the art of teaching mathematics. Additionally, prospective teachers are required to have a passing grade in the subject of at least one level higher than the division (primary or secondary) at which it was being taught.
- From September, 2009, all prospective teachers now have to be trained, before being assigned classroom duties of teaching students. Additionally, since workplace on-the-job training is no longer a feature of workplace employment for low skilled workers, the Ministry of Education has had to fulfil its visionary

statement of being the ’foremost provider of training for the development of all persons’ (Ministry of Education Policy Makers).

- Because in most workplaces, employers are engaging a variety of technological tools to assist employees in the workplace, the mathematical algorithms informing the operation of these tools, which are hidden in black boxes (devices which prevent one from seeing the algorithm when the tools are being used) have now become topics of classroom lessons. Teachers therefore are responsible to ensure that knowledge of the mathematics in use in the workplaces is known to students. As one enters the era where curriculum is informed by a constructionist mode and therefore rote learning is discouraged, visits to workplaces have now become a timetabled event on the school’s classroom calendar. This is a complete turn-about from a few years, when no visit was made to workplaces and where also there was no communication between classroom teachers and employers. All this has changed since employers have laid out specific attributes required for hiring of new employees at their workplaces. Therefore design of classroom curriculum should incorporate information obtained from workplaces.

  On the contrary, so important is this notion for teachers to converse with employers, that it has become a mandatory clause, legislated in the Education Act, 2008. On the employer’s behalf there is a ‘Steering Committee,’ to fulfil this mandate. An advisory Committee appointed by the Minister of Education constitutes the Ministry of Education’s members around this table.

- To ensure that teachers are equipped for classroom duties the Ministry policy makers have worked with various stakeholders, in the society, (Device, Chinese Government, UNESCO, Family Dentistry and Associates, and Bargain centre) in order to improve and to strengthen our educational institutions, and to develop productive citizens. Today through the generosity of these stake holders every teacher in Antigua and Barbuda has been presented with a technological gadget and classroom tool a laptop, to help with their preparation of classroom lessons. This has therefore ensured that teachers could use several of the known mathematics software products to inform mathematics lessons. Additionally, computer literacy among the teaching fraternity has grown. Recently, students in fifth and fourth forms have now been given computer tablets. This is to meet the requirement for students, to be computer literate and to possess technological knowledge needed for workplace operations. No doubt the demands of employers impacted positively the acquisition of these devices for classroom lessons. Hence teachers' mathematics lessons are no longer confined to the chalk-and-talk strategy.

Whereas the mission statement of the Ministry of Education speaks to the notion of its being the foremost provider of training for the development of the individual, the clause stating that this training would allow for individual working independently has had to be reworded to incorporate the development of a process of collaborative and cooperation. This is to cater for teamwork which is an important characteristic among workers in the workplace. Prior to introduction of the constructionist mode to the curriculum the behaviourist era was characterised by students working as individual entity. Teamwork is now part of mathematics classroom lessons. This observation was supported by the Director of Education who stated that:

> *...in terms of what happens at the workplace, you have to be able to work together with people. Now-a-days teachers are encouraging team work with students. They are doing a project, and they work in teams. Teachers are putting persons in groups and I also notice what teachers are doing is that they are putting persons to work in groups where strong persons can help the weaker ones of the group. .....I am thinking about interpersonal relationships, where children are encouraged to get along with each other; and that comes out a lot......And the whole idea of conflict resolution and anger management: so we are different what you say I might not agree with, but it's all right. And respect b for another person's opinion. So that when once they learn these things, they should be able to go into workplace and be able to get along with their workmates.*

This also testifies to the fact that ontological principles are now part of classroom mathematics lessons. This would find credence with Barnett's (2007) admonition imploring teachers to 'not only teach their subjects, but rather to also teach the subjects'.

- Whereas most industries in Antigua and Barbuda are dependent upon direct foreign investment for capital, this has resulted in students in classrooms to include mathematics classroom being prepared for a three tier citizenship lifestyle. Investors are now heavily engaged in outsourcing choosing to make low tax havens and countries of cheap labour homeland to their business. Sometimes their employees from a low salary jurisdiction get sent to another business enterprise, away from their homeland. Especially if the investors own a chain of businesses.
- Hence it is possible for workers from third world countries to be assigned to establishments in first world countries. Technological knowledge and other techno-mathematical literacies must be parallel to ensure that this human transaction could be employed. Hence school's mathematics curriculum content should embrace the global dimension and not only cater for a third world mono-cultural economy.
- Finally all students in the mathematics classroom should be able to talk the jargon associated with explanation of any mathematical concept. A good command of the English language is therefore necessary. The importance of this quality becomes very prominent at breakdown moments when employees located at different parts of the globe have to resolve a problem using a telephone. These are some of the demands now being made on mathematics teachers based on the requirement of employers for their workplaces and the type of business informing their establishment.

I argue that, non-conformance with these requirements for the preparation of students for workplaces to meet specified employers' demands, could only result in the products from the Antigua and Barbuda Education system being marginalized, in any techno-mathematical literacy, industrial, climate in the economy and comprising the labour force of the 21st Century. Indeed maximum profit from their investments is the goal of every investor.

7.12.2 Implications of Workforce Mathematical Needs for Curriculum and Quality of Teaching

The mathematical needs of students entering the work force indicate that a work to job transition programme would be beneficial for all students including mathematics students. The cause comes from the differences in roles the newly employed would assume in the workplace in contrast to what was the previous role in schools. Whereas in a school's environment it is the norm for most students to be told what task to perform, in the workplace, these same students, now as employees would be expected to use their initiatives, to act as a collective unit and not this lonesome person, working as a unit, as was encouraged in school's classroom environment.

Similarly, the expectation of the employers concerning independent labour was that of having the employees, not waiting to be told what to do but rather to act on one's feet, thus making informed, independent and constructive decisions. Achieving this feat could include field visits to worksites, vacation attachments and job interaction with professionals working in different fields.

It also indicates that utilising real world mathematical examples in teaching class room based mathematics would be beneficial. Use of technological tools in class room based mathematics is also a crucial component to better equip students to the reality of real work mathematics experience.

This brings into sharp focus the need for creativity from teachers, in text books and an adjustment in the curriculum at least for the first three years of secondary school when the domineering influence of CXC examinations is not as constraining. In fact:

> *The mathematics curriculum should allow time, space and freedom for students to discover, and taking the learners interests into account; as well as experience using their developing mathematical knowledge, skills and understanding in*

increasingly complex situations and also real world job based activities (Wake, 2011, p.3).

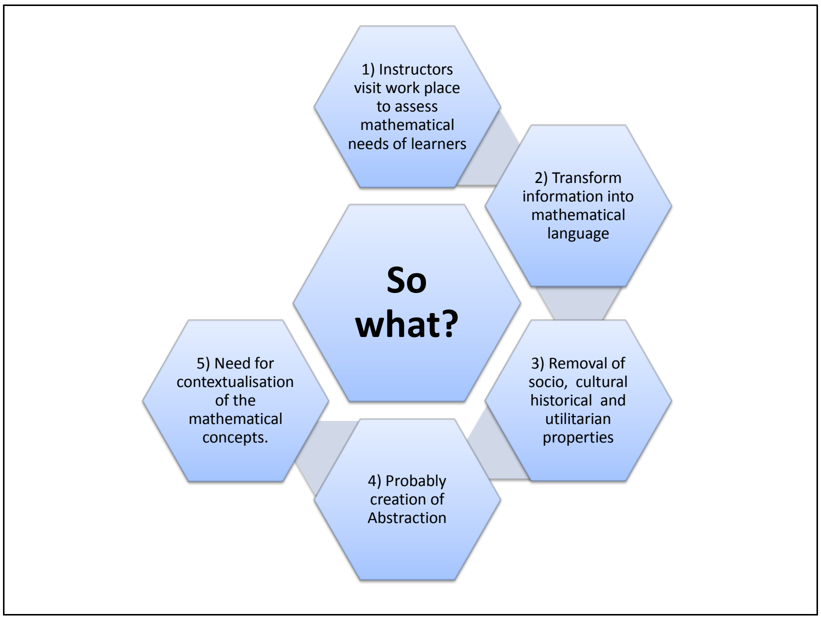
Teachers therefore need to be more creative in presenting their mathematics lessons utilising real work experience drawn from the sectors and jobs Secondary School graduates would be taking up (Ferrari, Cachia, and Punie, 2009, pp.5-6).

Creativity has been defined as a product or process that shows a balance of originality and value. It is a skill, an ability to make unforeseen connections and to generate new and appropriate ideas. Creative learning is therefore any learning which involves understanding and new awareness, which allows the learner to go beyond notional acquisition, and focuses on thinking skills. It is based on learner empowerment and centeredness (Ferrari, Cachia, and Punie, 2009, pp.5-6).

Innovative teaching is the process leading to creative learning, the implementation of new methods, tools and contents which could benefit learners and their creative potential (Ferrari, Cachia, and Punie, 2009, pp.5-6).

Abstraction in mathematics lessons can lead to boredom and can be a barrier to learning for students who are motivated by lessons anchored in their reality and relevant to jobs for which they are likely to be employed. Figure 7.1 highlights some of the probable cause of abstraction in our mathematics classrooms in Antigua and Barbuda and offers suggestion for remedial action.

Figure 7: Probable cause of abstraction in classroom mathematics lessons



The traditional objectives of teaching taught in training centres for teachers, include:

- Remembering
- Understanding
- Applying
- Analysing
- Evaluating
- Creating

These objectives are generally applied in a hierarchical manner, with creativity viewed as the last objective, hardly utilised and only after the preceding teaching objectives have been met. Creative learning requires *innovative teaching*. Innovative teaching is both the practice of teaching for creativity and of applying innovation to teaching (Ferrari, et. al., 2009).

Assessment methods would also require adjustment to facilitate creativity to flourish by valuing it, both at micro, everyday level and at macro, examination level. The three functions of assessment (diagnostic, formative, and summative) must contribute to the development of both knowledge acquisition and skills development for learning and creating (Ferrari, Cachia, and Punie, 2009).

While training of teachers in the art of teaching exposes teachers to the modules, with their purposes and objectives listed in Table 7.14- Table 7.15, seemingly the most important contribution to teachers' professional growth lies in its allowance for acquisition of certification (qualification) rather than in its contribution leading to teachers making use of better teaching methods, innovative strategies and techniques while delivering information to taught mathematical concepts and confidence of teachers, in teaching of different mathematical topics during class lessons. Notably absent from the modules informing professional training are affiliations of mathematics topics to the workplace and their relevance to students' way of life.

Thus failure of teachers to display motivational, creative and constructive mode of operations in their classroom mathematics lessons; subsequent to two years training from the Antiguan and Barbuda's *Teacher Training Department*, have led to my claim of the need for a reconstruction of teaching standards, performance and accountability (Mahony and Hextall, 2000). The modules, their purposes and their objectives, presently informing the teacher training program comprise the content of tables 7.14 and 7.15.

Table 7.14: Modules Forming Content of Teacher Training Programme in Antigua and Barbuda, 2009, for New Employees

Source: Head of Teacher Training Department, 2009.

Modules	Purposes	Objectives
MA 205 Advanced concepts in mathematics	The main purpose of this course is to provide secondary school mathematics teachers with content knowledge and mathematical competence at a level beyond the level of teaching. The course assumes a good knowledge of basic mathematics concepts to at least the secondary level.	I) To help the participants to develop higher levels of mathematics competence. ii) To foster appreciation for selected topics in mathematics.
MAT 102 Promoting understanding of key concepts in Primary Mathematics	The main purpose is to present participants with practical strategies for helping students in the primary grades to develop a sound understanding of concepts that they must learn at this level. The course should be delivered in such a way as to help participants to develop an understanding of concepts.	To expose participants to Instructional approaches appropriate to students in the primary grades. To expose participants to strategies which promote understanding of mathematical idea related to strand taught at the primary level.

Table 7.15: Other Modules Forming Content of Teacher Training Programme in Antigua and Barbuda, 2009, for New Employees

Source: Head of Teacher Training Department, 2009.

Modules	**Purposes**	**Objectives**
MAT 201 Issues in Teaching and Learning mathematics at secondary level.	Issues in teaching and learning mathematics at the secondary level are the first course for teachers specializing in mathematics education. Hence the course is designed to lay the foundation for the other courses. It also provides/several of the issues of which secondary mathematics Teachers should be aware. These include: I) Learning theories that influence how mathematics is taught; Ii) Matters relating to making and implementing plans for assessment and instruction; iii) Ideas about the use of technology in mathematics classrooms; iv) Scope and sequence of the mathematics that is taught in secondary schools across the region; v) Notion of promoting critical thinking among students in secondary mathematics classrooms.	To raise awareness of theoretical foundations related to learning and teaching mathematics at the secondary level; To raise awareness of issues related to teaching and learning mathematics in Caribbean classroom; To provide participants with skills of assessment, planning and delivering mathematics instruction at the secondary level; To expose participants to concepts related to promoting critical thinking in secondary mathematics classrooms.
MAT 204 Developing geometry and Trigonometry concepts in the secondary classroom	Not available	Not available

7.13 Summary

In this chapter, I use the data from the employers' worksites, to address the second subsidiary question*: What is the impact of employers' mathematical needs on mathematics education in secondary schools of Antigua and Barbuda?* The suggestions emerging from the analysis of the data were that, generally, for jobs which secondary students could access, the mathematics requirement gap was closed, by on-the-job training, utilisation of black boxes or technological tools that reduced highly complex mathematics requirements to simple procedures. Adjustment to curriculum, to teaching method and assessment were seen as in need of changes; specifically carving out more time for creative learning, using technology, on the job experience and adjusting the assessment process utilising more formative assessment.

Chapter 8 - Tensions Between School Mathematics the Workplace

8.1 Introduction

The development, growth and diversity in the economy of Antigua and Barbuda cannot be separated from the island's history. For it was in the process of carving out the island's history that the wheels of the economy were driven to fashion and build the structure, leading to the dominance of specific types of activities. These activities in turn gave the economy its character. History would reveal therefore that at different periods of the island's development, distinct categories of workers were in demand to ensure that the building of a nation was on the right path. Indeed, with the exception of one era where the job market was sourced by slave and indentured labourers, the country's education system has always been the vehicle responsible for providing the workers for the labour force. Consequently, in this chapter, I present my account of the Island's economy, from a historical perspective. The following subheadings are used to signpost the sections: (i) an account of the discovery of the island; (ii) its colonization; (iii) its status as a colony of Britain; (iv) its subsequent rise to status of statehood in association with Britain and (v) finally to its ascendancy of an independent sovereign state with the Monarchy of Britain, still as the head of state. Diurnal representation is by a Governor General.

In economic jargon the Antigua and Barbuda economy falls into the category of an open economy. Therefore most of its economic activities will be affected by the state of affairs in the global market. It is also a country that imports more goods than it exports. There were five distinct phases in the growth and development of this island's economy. They include

- 1492-1632 - period of discovery and colonization.
- 1632-1834 - period of colonization spanning period of the slave trade.

- 1834-1968 - status as one of the overseas colonies of Britain and the formation of its open economy.
- 1968-1981 - Change in status to assume Statehood in Association with Britain.
- 1981-present - Independent Sovereign Twin Island State, with Monarchy of Britain as its head of state (Symbolically represented by the Governor General).

I claim that simultaneously with economic diversity came changes in the education culture prevailing on the island. During the period 1492-1632, because it was subsequent to the discovery of the island by Christopher Columbus, there was no trading with other nations. The inhabitants known as the Siboneys were pursuing a simple nomadic way of life. This included growing of agricultural crops for self-maintenance and fishing to supply most of their meat. There was no formal education system. But by 1632-1834 there was trading with other nations-mainly Britain. For once Sir Thomas Warner had colonized the island on behalf of the British Monarchy - sugar became the merchandise for trade. The crop from which the sugar was manufactured, sugar cane, demanded a large unskilled labour force. Slaves from the different trading posts in Africa were used to fill this requirement. Thus began the lucrative slave trade from Africa to the Caribbean Island of Antigua and Barbuda.

It was around this time (1764) that Methodism was introduced into Antigua and Barbuda. Prior to this there was the arrival of the Moravians (1756). Both were obsessed with preaching the Christian doctrine, which resulted in the conversion of the slaves to this new religion. Teaching the slaves to read and write were the other activities occupying the missionaries. This was the beginning of formal education on the island. The textbook was the Christian Bible. After years of the slave trade its abolition took place in 1834. For the next hundred years this abolition saw the growth and development of a formal education system. This period 1834-1968 was the period too, where Britain was in total control of the island. Thus all positions of Government to include management of the entire welfare of the country were manned by expatriates, who were top civil servants from England.

To ensure the continuity and to accommodate the education of the children for these expatriate civil servants, an education system based on the British Westminster model was introduced into the island. Official examinations organised by the General Certificate Examination Councils of Cambridge University and London University became the examination boards with the mandate to provide school leavers with certificates to testify their success of having gained passes in the listed subjects at the 11^{th} Grade level of secondary schools tuition. This was the modus operandi of the external education format until the year 1979, when there was a change in policy to embrace and adopt the Caribbean Examination Council Board of examination as the Island's official examination body for secondary school leavers.

The role played by the education system at these various periods in the island's history was the subject for further analysis in the chapter. Similarly the account of the simultaneous development of the economy also formed part of the analysis. This analysis and description of the island's economic activities and the island's education system foregrounded the research question, the focus of this thesis: *given the increase in technological tools in the labour market in Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the workplace?*

8.2 Tensions between School Mathematics and Workplace Mathematics

In this section I present analysis to the main research question: *given the increase in technological tools in the labour market in Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the workplace?* The main focus of my analysis is the examination of the curricula used to teach mathematics in classrooms for specific periods in the island’s history (1832-2009) and their impact on preparation of school leavers for the job market, where mathematics is a part of daily routine. I begin by highlighting each of the known mathematics curricula that were used at particular periods in the labour market during the development of the economy, education system and the society at large. Table 8.1 Provides details of the exact periods contributing to my analysis of tensions between teaching school mathematics and preparing young people for the job market, given the increase in the use of technological tools at the workplaces where mathematics is a part of daily routine.

I begin the analysis from the period 1834-1968. Although seemingly the history of Antigua and Barbuda had its inception in 1492, from the historical account of the twin Island State in Chapter 2, I argue that during the period 1492-1834, because the island was in the control of a foreign power, Britain, mathematics education was at its lowest ebb and virtually non-existent among the indigenous Antigua and Barbuda citizens. In fact it was a society in which the slave trade supplied workers for the labour market. The slaves were also properties of the colonial masters. Allegedly these slaves were treated as tools; their work hours spanned sunrise to sunset. The main form of activities at work was agrarian, where tendering and caring for the young sugar plant and then harvesting of the crop in preparation for the final produce of sugar production, kept these employees busy.

The employees (slaves) had no control over their destiny. Attending school was never an option for them (Hurst, 2012, Henry, 1988, Richards, 1983). In fact in the view of the colonial masters “ignorance in terms of keeping workers illiterate and lacking in numeracy skills were bliss” (Vere Cornwall Bird). Thus no analysis focussing on formal mathematics education is possible during this period. The value of the formal education resided in the religious content taught to the slaves during their free days by the Moravian Pastors (1756) and the Methodist Preachers (1764).

Subsequently the story of school mathematics and its impact on the appropriate preparation of students to handle mathematics in the Antigua and Barbuda workplaces could be credited with an inaugural date of 1834-1968. Table 8.1 signposts the benefits accruing from this formal mathematics education for the labour market and the employees.

Table 8.1: Certificates Awarded to School Leavers as Matriculation for Jobs in the Workplace

Period	**Educational Tools**	**Graduates' Certificates**	**Categories for employees of the labour market**
1834-1968	*Text books with* *Mathematics exercises* *Based on the content of the mathematics syllabus informing classroom lessons.* *Examination Boards were: Universities of Cambridge and of London (for overseas students*	Seventh Standard (Primary, 1834-1949)(Hurst, 2012) Secondary school leaving certificates comprised: 1949-1963 High school l Education Certificate 1963-1979- General Certificate in Education from the Universities of Cambridge and London for overseas students (Hurst, 2012)	Unskilled Skilled Semi-professional Professional

During the period 1834-1930, there was a change in economic activities in the islands following the emancipation of the slaves from the colonial powers. However, as the infrastructure of the local economy had not been developed, the only economic activities that could command the numbers for a work force was still employment on the estates (Hurst, 2012; Henry, 1988; Richards,1983). This situation existed since 'the means of production were historically placed in the hands of absentee owners, while profits also went to those owners, domiciled in the European Country and thus leaving the [indigenous natives] impoverished' (Hurst 2012, p.286). There were very few acres of unclaimed lands available to the post emancipation citizens who sought to terminate their link with the plantation/estate life. Those who left the estates were soon engaged once more with some activity associated with agriculture (see Smith and Smith, 1988. *To Shoot Hard Labour).*

Attendance at formal classes in mathematics was not a way of life for most natives of this era. Hence mathematics education played no significant role in the lives of these employees. However many of the activities in this agricultural based economy did in fact have a mathematical base (see Chapter 7, subsection for the activities informing the work of the gardeners). For example digging of holes to plant young cane suckers, the ratio of each dose of chemical required to form mixture for fertilizers, the amount of water to administer to the plant, the correct temperature and hence location where certain plants/crops species should be planted to provide maximum yield and composition of the soil to name a few. Preparing pay rolls, pay sheets, recording of money spent and money collected, would also involve mathematics operations. Since the properties were owned by foreign power, currency exchange rates were also very important. Ordering of agricultural machinery and parts for machines would have incurred some importation taxes, hence the role of mathematics again.

Indeed, since the natives were not aware of the relevance of the mathematics informing their work there was no tension between what the religious pastors were teaching and non-preparation of the labourers to handle the mathematics in their daily chaos. In the opinion of these employees their work was an activity.

Nevertheless, in the early 1930s and the late 1940s, when the natives began to agitate for better working conditions, more wages and overall higher standard of living to include housing and utility services, there was more diversification in economic activities. This revolution for a better way of life for natives in the late 1930s and late 1940s was championed by Vere Cornwall Bird and his foot soldiers to include: Lionel Hurst, Hawkins

Lake, Denfield Hurst, Ernest Williams, Joseph Myers, Lionel Stevens, Luther George, Reginald Stevens, Novelle Richards (See Chapter2: Richards, 1963, Hurst, 2012). The claim was also for a right to an education. The freedom fighters on behalf of the natives were all members of the governing legislature. Elections to the positions required that all voters should be educated and thus these leaders were keen for the masses, who were their supporters to acquire literacy and numeracy. The right for an education was won in 1951 with their achievement of Adults Suffrage: the right to vote, one man, one vote (Richards, 1983, henry, 1988, Hurst, 2012). In the 1951 Leeward Islands Report:

> *Reading, writing, arithmetic, English Language, English Literature, moral instruction, tropical hygiene, elementary science, with gardening and pot culture, geography and history, singing, physical exercise, and needlework (for girls) were the obligatory subjects. The optional subjects included handicraft or wood craft (Hurst, 2012, p.187).*

According to Hurst (2012, p.198):

> *Transformation of education could not possibly take place without new buildings, new teachers, new books, and other costly tools. A new more productive economy had to be created that would generate new wealth, more equitably distributed, to enable greater availability of places in many more schools (Hurst, 2012, p.198).*

Simultaneously:

> *Diversification of the economy therefore started. The December 1950 law permitted the entry of machinery, parts, supplies and raw materials into Antigua and Barbuda. An Industrial Development Board (IDB) was created under law in order to manage the demand and to meet the requirements of a new industrial economy (Richards, 1963, p.119).*

Antigua and Barbuda would experience Industrialization by invitation (Dr Arthur Lewis, 2003). This period was followed by an exercise designed to ensure that there was a school in every village in Antigua and Barbuda (see Appendix 8.1). By the end of 1968, there were eight secondary schools on the twin island state: Antigua Grammar school (1884), Antigua Girls High school (1886), Princess Margaret School (1955), All Saints Secondary (1963), Jennings Secondary (1965), Roman Catholic Convent (1955), Hill Secondary (1950), and Henry Secondary (1950), the last three being private institutions. I would argue that this could have been designated the period where formal assessment of the tensions between taught mathematics lessons in schools and the task of appropriately preparing students for the workplace to handle the mathematics in work had its origin, in the twin Island state of Antigua and Barbuda.

In my research this analysis is limited to six government secondary schools. Thus the analysis to examine whether with the increase in technological tools in the work force of Antigua and Barbuda, there are tensions between the mathematics taught in schools and the appropriate preparation of students to handle the mathematics in the workplace provides the content for the subsequent paragraphs of the next section.

8.3 Antigua and Barbuda: Impact of Mathematics Education 1968-2009

By 1967 Antigua and Barbuda had achieved the status of Statehood in Association with Britain. Therefore, while England was still in charge of external affairs for the island, the Legislative Body in charge of the local government was in control of internal affairs. This was matched by the slogan in local parlance that we were now in charge of our own destiny. In the economy there was an increase in local activities with a diversification from a monoculture economy (sugar industry the sole industry) to a service (to include industrialization) economy (see Chapter 2). The introduction of the tourist industry, with its multiplicity of spin off workplace activities could be directly responsible for this diversification in the economy. Additionally, the introduction of the tourism industry impacted positively the construction industry, to meet the demands for rooms to accommodate the tourists. There was also the need to construct not only hotels but also roads, expansion of electricity and water supplies, need to ensure that communication with the outer world was in keeping with that of 21st century, hence the need for the latest technological devices to be a part of the island's infrastructure as far as utility was concerned. There was need for land and sea transportation. All this called for cruise industry and aviation facilities; meteorologist to man the weather office, air traffic control persons to man the air traffic and local deep water harbour and port to berth the ocean going cruise ships which provided sea transportation. Hence not only unskilled labourers but rather highly skilled workers were now required in the labour market. Seemingly all this took place in a very short time, immediately following the departure of the colonial powers.

As recorded by Hurst (2012, p.203) in the bibliography of V.C. Bird:

> *A new Antigua and Barbuda was created from the dustbin of bagasse. Vere Bird commandeered the establishment of several new industries which created new opportunities for profits and employment. These included: a cornmeal factory, an edible oil factory, a sausage factory, a shoemaking factory, an arrowroot factory and an oil refinery were established. Other enterprises were the entrepreneurs' industrial size laundry, to handle the demands from new hotels and a dry-cleaning plant to meet the new demands of an expanded middle-class/office workforce. A new block making and mixed cement plant came into being to enable construction. Similarly earth-moving vehicles multiplied to meet the demand for ever larger construction projects. The new automobiles, the trucks, the pick-ups, even the motor scooters began to multiply.*
>
> *George Benjamin began recapping used tires in a huge plant on New Gate Street. As wealth increased, the number of vehicles soared; a correlated demand for replaceable parts surged. New businesses found niches requiring their goods and services*

The mathematics lessons taught in school should have paralleled the new diversification in the once monoculture economy. Noticeable also was the fact that when the colonial masters were in control, all technicians to fill highly skilled and other managerial positions were flown out to the colonies from Britain. With local government now in control of their own destiny, these were now the local government's responsibility. Hence, with the diversification of the economy and the need for highly skilled technicians to man the technological devices now informing part of workplace operations, the relevant engineers, contractors, meteorologists, accountants, insurance agents, technical vocational teachers, information technology specialists, education officers, auto mechanic operators and mathematics teachers were in demand. The secondary school had been assigned the role (Education Act, 1973) of providing as far as possible the necessary persons. Where higher education was required government would ensure that the individuals were given the opportunity to pursue that mission. Therefore, in this analysis, where the focus is on mathematics taught in the secondary schools and the value of such lessons in appropriate preparation of school leavers for the mathematical operations at their future workplaces, I now turn my attention to the composition of the certificates awarded graduates from the secondary schools. A historical paradigm informs the analysis of the data I collected from participants. I also draw on the work of Antigua and Barbuda Historians now Authors of several books.

As seen in Table 8.1, there were four categories of certificates awarded to school leavers during the period 1834-1968. The Seventh Standard Certificate by 1935 was declared as inadequate (Richards, 1963) for the society in which it should have been functional. Recall that the content of the mathematics syllabus was premised on a heavy arithmetical base. However the society had expanded and more infrastructures were now incorporated to make it more complex than the society prior to 1834. While the mathematics prior to 1834 was the simple branch of consumer arithmetic, the expansion of the economy also included the use of technological tools that were now a part of workplace activities. Hence the syllabus being taught in schools would have been inadequate for appropriate preparation of school leavers for the workplace. Additionally, this certificate was only at a primary level. The society had moved beyond this phase. There was therefore a gap in knowledge content and in skills associated with mathematical operations in work and in using the technological tools.

It was for this reason that the decision for on-the-job training (Antigua and Barbuda employers) was such a critical and necessary asset for employers, who made it a permanent fixture at all workplaces when new employees were brought into their workplaces. For despite the diversification of the economy most of the labourers resided in the low skilled and agricultural sector of the economy. Their level of education was just primary where only arithmetic was taught.

8.4 Secondary Mathematics Education

The quest for a better life was responsible for the great desire and interest exhibited by the descendants of the freed slaves, for secondary education. This resulted from the view they held of learning and of formal education being vehicles that could lift generations out of poverty. Hence they were determined to use this vehicle of secondary education to escape the horrors of colonial Antigua and Barbuda (Hurst, 2012). Initially, secondary education could have been acquired at:

> *5 Private Secondary Schools, 4 of these schools received grants from public funds to assist with resources to support learning. Approximately 3% of the total elementary school population attended the secondary schools. A number of this percentage did not complete their secondary school course (Hurst, 2012, p.187).*

Therefore, it could not have been possible to build an informed and educated nation with this small number of people (3% of 12000). Thus from:

> *1951-1971 the drive to create additional opportunities for youth began with the building of new schools and the training of new teachers. The Vere Cornwall Bird's and the Antigua and Barbuda Labour Union objective of making primary and secondary education universally available, free of cost to parents, and compulsory, was the start of a revolution which required the full participation of all the people of Antigua and Barbuda, especially the poor and the down trodden. There was a continuous hunger for knowledge and new skills, and all parents accepted the notion that education would provide an avenue for higher incomes and status. The Report on the Education Departments for the Leeward Islands Colony, 1952, numbered by paragraphs tells the early story of that revolution (Hurst, 2012, p.182).*

In one of these paragraphs, it was reported that in 1955 the first government secondary school, the Princess Margaret was opened, thus bringing to fruition that ambition for Universal Secondary Education. This became a reality in 1966 (Hurst, 2012). The first school leaving certificate at the secondary school level was the *Higher Education Certificate* (1949-1963) (Dame Harris and Cordelle). The branches of the mathematics paradigm informing the mathematics syllabus for this certificate included: Arithmetic, Geometry, Algebra, and trigonometry.

I argue that the expectation for ***Geometry*** could have been based on knowledge to include:

> *First the world is built of shape and space, and geometry is its mathematics.*

Second informal geometry is good preparation. Students have trouble with abstraction if they lack sufficient experience with more concrete materials and activities.

Third geometry has more application than just within the field itself. Often students can solve problems from other fields more easily when they represent the problems geometrically.

Finally, many people think well visually. Geometry can be a doorway to their success in mathematics (National Research Council Workshop, 1995).

http://www.curriculumsupport.education.asw.gov.ausecondary/mathematics/cross curriculum/vocational/voc .ed.htm [accessed on, 07/02/2013]

Arithmetic: content for the arithmetic branch included: multiplication tables, counting using number theory, measurements, percentages, fractions and application to introduction to business theory in respect to stocks and shares calculations. Students were also introduced to conversion of British system of measurement (inches, feet, yards) to the metric system of measurement (millimetre, centimetre, kilometre, grams, kilograms) since these units of measurement were required for the science subjects: Physics, Biology, and Chemistry (Cordell).

Aim of the content of the arithmetic syllabus was to address the need of providing students with capacity and capability to be employed directly as Clerks in the Administration offices of the sugar industry. Hence it was preparing school leavers for the world of work immediately upon graduation from secondary school (Cordell).

Algebra: content for the algebra branch included addition multiplication, division and subtraction of terms with the same variables, simultaneous equations, linear equations, problem solving, using given information to form simultaneous equations, linear equations, and to solve these equations.

Aim: Algebra played a supporting role to the Arithmetic content in that it gave the students the skill to solve problems in the abstract manner. For example, where students had to use variables x and y to show the relationship between different quantities in making connections to given information. It also allowed students to develop relationships between variables in a given situation. This provided students with the necessary skills to become laboratory technicians and could thus fill vacancies in the laboratories of the newly introduced West Indies Oil Company, the Quantity Surveying Offices in the Ministry of Work. Hence the Government of Antigua and Barbuda was able to provide employees to address the expansion and development of the Nation's infrastructure to include construction of roads and buildings, to enhance the diversification program of employable activities, introduced in the economy in the sixties.

Geometry: content for the geometric branch of the mathematics syllabus included definition of points, ray, line, line segment, polygons, circles, angles and different types of lines, different theorems with their proofs, properties of parallel straight lines and their angles, and construction exercises (Cordell).

Aim: (given collectively with the Trigonometry)

Trigonometry: content included Pythagoras' theorem and the trigonometric functions of Sine, Cosine, and Tangent, with their definitions. It also involved use of Tables associated with the values for angles associated with the trigonometric functions when solving problems (Cordell).

Aim: the Geometry and the Trigonometry provided students with the theoretical knowledge to complement their trade skills in carpentry, masonry, surveying and plumbing. This came at a time in the development of the country, where University trained professionals returning to work in the country were able to use graduates from the secondary schools as apprentices to fill positions in areas to include: drafting, laboratory technicians, surveying cadets, Quantity surveyors and laboratory technologists (Cordell).

Additionally it prepared the students to go to the next level of the Higher School Certificate in mathematics. This Higher school Certificate in Mathematics was required for matriculation purposes to enter University. Thus while the school leavers entering directly into the workforce were equipped with skills to handle the mathematics that was part of daily job routine, the main aim of the mathematics programme of the Higher

Education Certificate was to prepare students to enter University to pursue professional training in science and engineering. In this same era most parents wanted their children to enter university to pursue studies in sciences to lead to degrees as doctors or civil engineers (Cordell).

Conclusion

Emerging from this data is information to suggest that the mathematics syllabus for the Higher Education Certificate for school leavers fulfilled a dual role of (i) providing school leavers who entered directly into the workforce upon graduation with adequate skills to handle mathematics in the job market and (ii) providing candidates wishing to pursue training at University with the matriculation necessities. Hence I would conclude that the secondary school mathematics content during the period 1949-1963 was relevant to the needs of the Antiguan and Barbuda society.

8.5 Secondary Schools' Mathematics Lessons Informing Cambridge and London Certificates (1963-1979)

The remaining two certificates in Table 8.1 were associated with mathematics syllabi premised on content from the University of Cambridge and the University of London for overseas students (1963-1979). While the topics constituting content of both syllabi were identical, the Cambridge syllabus was informing the mathematics lessons in secondary schools, while the syllabus for the London University informed the mathematics for private candidates and post-secondary school institutions. Informing these mathematics syllabi were three branches of the mathematics spectrum: arithmetic, algebra and geometry. There was no practical component to these three branches of mathematics accompanying any of the theoretical concepts being taught in classrooms. All classroom lessons were founded upon a comprehensive theoretical base. In most of the cases no connection was made between taught mathematical concepts and any aspect of real world situations. Neither was there any connection with any of the other disciplines being taught in the school's curriculum. This was a failure on the part of the teachers to guide students in the making of such connections.

Students were prepared for the **Arithmetical** content of the syllabus using a text book, entitled: *A New Course in Arithmetic*: the content comprised, number theory, fractions, Mensuration, Rules for multiplication, addition, subtraction and division, percentages, ratio and proportion, area, volume, money, conversion from one unit to another, S.I. Unit of measurement, Imperial Unit, capacity, problem solving and multiplication tables (2x-12x).

The **aim** was the same as that for the High Education Certificate's.

The **Algebraic** content of the syllabus was similarly taught from a textbook captioned: *A New Course in Algebra.* Topics included: addition, multiplication, subtraction and division of simple algebraic terms, solving linear equations, simultaneous equations, quadratic equations, drawing graphs, writing algebraic expressions for given arithmetical statements and English statements. Construction of simple linear equations and construction of simultaneous equations were also tasks engaging students' attention. The **aim** was the same as that of the High Education Certificate's.

Finally, the **Geometric** content was to be found in the text Book: *A New Course in Geometry.* Students were required to know by heart all the proofs associated with every geometric theorem cited as a content item. Additionally they were expected to use these theorems to solve geometrical problems. Another topic was polygons: regular and irregular three-ten sided figures, more where required; triangles, quadrilateral, pentagon, hexagon, heptagon, octagon, nonagon, decagon, how to find sum of interior angles of given regular polygons, convex polygons and re-entrant polygons. Knowledge was also demanded for: the different types of triangles (Similar, congruent, acute, Obtuse, right angle, isosceles, equilateral); solve problems relating to each type of triangle. Circles: name of each component of the circle to include diameter, radius (plural radii), circumference, sector, arc and all theorems associated with the circle.

Knowledge of area of circle, length of sector of circle and length of arc of circle using formulae were also to be known by heart. Additionally, Construction of any polygon, bisecting angles straight lines, and using given information to construct the given figure were skills made by the syllabus for learners to acquire. Definitions of: a point, a line segment, different type of angles (acute, obtuse, straight, reflex), different types of lines; oblique, vertical, horizontal, parallel and angles associated with parallel lines to include: corresponding angles, allied angles, alternate angles, vertically opposite angles; meanings for supplementary and complementary angles.

The **aim** was the same as that of the Higher Education Certificate's syllabus.

Conclusion

From the data I would conclude that there was no change in content of the mathematics syllabi informing classroom lessons. Seemingly the mathematics content should have been adequate for workplace activities. As I would also learn from participants of the research and who actually were recipients of mathematics lessons using the Higher Education Certificate (HEC) mathematics syllabus' content, the difference in content when the comparison was made with the Cambridge University's General Certificate of Education (GCE) and the London University's General Certificate of Education was only in name, the mathematical content was the same (Cordell). It would be expected that students opting for University degrees would have been for the majority, the children of the Colonial masters as only a few of the indigenous Antigua and Barbuda Parents could have afforded financially to support this mission. Hence for the purpose of matriculation, the mathematics content could have been sufficient.

However as seen in Tables 8.2, Table,8.3, and Table 8.4 respectively below, the requirements of employees directly entering the job market after graduation from secondary school had changed from the local and basic mathematics content to a higher level. The economy of Antigua and Barbuda had not only grown, but had changed from the monoculture sugar based economy, to a *Service* base led economy. This *Service* led economy required not only skills in medicine and engineering but also skills in computers and all their subsidiaries manifested in: graphics; communication engineers; computer programmers and computer analysts. Hence there was a change in the mathematics requirements from that to adequately meet the needs of a clerk to that of meeting the needs of different technologists and technicians; to facilitate the new industries with their increase in the use of technological tools and gadgets. The mathematics being taught in school was therefore not meeting the needs of the present Antigua and Barbuda labour market of that era.

Indeed, one should not see this as an opportunity to lay blame for this failure of the Cambridge's and London's General Certificate Education Mathematics Syllabi, with the constructors of the syllabi. One has to take into consideration that these syllabi, were originally developed to serve the educational needs of another economy, British. Hence in Antigua and Barbuda, one had adopted syllabi for another society, which was at a different stage of development (First world as compared to third world), to serve the economic activities outside its jurisdiction. Conditions in the economic activities were not identical to those of The British Economy, and therefore these syllabi were not a fit for purpose.

Additionally, the purpose for which the GCE syllabi were constructed, that for students pursuing the trajectory for tertiary education, was not the main purpose for which it was being used in Antigua and Barbuda. The roles for which it was being used in Antigua and Barbuda, were dual roles: (i) academicism and (ii) for preparing students for the workplace. Preparation of students for the workplace was not one of the mandates of the General Certificate Education Certificate of Cambridge or London University's syllabus. On the other hand an examination of the records would (1978 Statistical Education Report on Education in Antigua and Barbuda) (National Archives, Antigua and Barbuda) reveal that many indigenous Antiguans and Barbuda's did satisfy matriculation criteria for Universities in England, to include Oxford, Cambridge and London, using the GCE syllabi for Cambridge University and London University for overseas students.

Prospective candidates To the University of the West Indies also were successful using the results of the GCE mathematics syllabi as matriculation documents. Thus the onus was on the Antigua and Barbuda Education policy makers to review their decision to use certificates from the Cambridge and the London Examination Boards as certificates for secondary school leavers in Antigua and Barbuda. This was done. Hence in 1979 The Caribbean Examination Council Board was assigned the mandate to be the examination Board for all secondary school leavers of Antigua and Barbuda.

Table 8.2: Nature of the Content of Mathematics Lessons in Schools and Labour Market Needs of Employees in Antigua and Barbuda

Period	**Mathematical Tools**	**Graduates' Certificates**	**Categories for employees of the labour market**
1963-1979 Status of Statehood in Association with Britain.	Text with content informing syllabi for Examination Boards of Cambridge University for overseas candidates and London University Examination Board for overseas candidates.	Cambridge GCE; London GCE	Unskilled(minority) Skilled (majority) Trades men Professionals Polyvalent

Table 8.3: Mathematical Needs of Workers at Various Worksites in Antigua and Barbuda

Pastry Chef and General Chef	**Human and Resource Training**	**Garage**	**Garage continued**
Personality Temperature Using a scale Measurement: Metric and imperial Health and safety regulation for food preparation Good behavior, keep themselves groomed, know how to approach customers, and show curiosity	Use of calculator Computer Arithmetical operations – especially division How to deal with customers Things to avoid Be responsible Leadership qualities Communicative skills Good command of the English language Fractions, decimal, percentage BOMDAS Tables Simple conversion Need for foundation in mathematics	Conversion of units from one system of measurement to the other: SI Unit To empirical Judgement; Changing oil, Selecting correct sizes, Fraction, volume Read charts Knowledge of how to operate the technological machines associated with specific jobs, example the lathe and the micrometre	Teamwork leadership qualities able to make decisions on one's feet Take responsibility for one's action.

Table 8.4: Mathematics Associated with the Work of Some Hotel Workers

Sales personal	House keeping	Bar	Bar continued
Being Analytical Constructing a Budget for a Project Simple basic rules for mathematics Associating mathematics Topicswith real life situations Be brave Willing to take on challenges Be assertive Information about the job for which employment was being sort Adaptable to all situations How to relate to customers Good command of the English language Multi-task level of professionalism	Take responsibility Accountability Simple calculations to include multiplication, Division, addition and subtraction To be positive Customer service technique Work as a member of a team Knowledge of the trade Tolerance, faith and humility Service need orientated industry, therefore need to be hospitable Love what they do Cooperation. Have to be willing to serve Focus on the job Computer Knowledge	Feel for the restaurant Personality Cheerful Undergo training in position known as Bar Back: assist Bar tender and thus get a field for what takes place in a bar. Training in mixology: correct ingredient for mixing and blending drinks Newly employed get a feel for what's happening in the bar by shadowing more experienced workers Holistic development 6weeks on the job training offered Philosophy: hire the personality and train the skill Mathematics is in the tool: example,	Holistic development 6weeks on the job training offered Philosophy: hire the personality and train the skill Mathematics is in the tool: example Jigger, ounce pourer, and cash register Knowledge of how to operate the tools associated with working in the bar and restaurant. Estimation of an ounce Measurement

8.6 Secondary School Mathematics Lessons (1979-present)

Table 8.5: Mathematics Required by Employees for the Job Market

Period	Mathematical Tool	Examination Board	Categories of workers
1979-Present Independent sovereign State	Based on recommended text for the Caribbean Examination Council	Caribbean Examination Council (CXC	Unskilled (Minority) Skilled (Majority) Tradesmen Professionals Polyvalent

The switch to the Caribbean Examination syllabus took place in 1979 as seen in Table 8.5 above. Prior to the move by Antigua and Barbuda the Caribbean Examination Council Board had been in operation for 11 years. The delay, I was told, (Minister of Education) was due to the Antiguan and Barbuda government waiting for assurance from renowned Universities Globally, that the secondary school leaving certificates issued by the Caribbean Examination Council Board could be used for matriculation by future scholars from Antigua and Barbuda seeking entrance to their Universities. Confirmation having been received, Antigua and Barbuda was ready to join counterparts in the OECS organisation in this new mission. Historically there were two syllabi: Basic Proficiency and General Proficiency. The Basic was the syllabus designed for students leaving school and entering directly into the workforce. The General proficiency syllabus was designed to meet the needs of students following trajectory for academicism and hoping to pursue higher studies in mathematics.

Controversy arose when led by the Antiguan Government the basic certificate was refused as matriculation for the workplace. Soon private employers adopted the same policy and stipulated that only the General Proficiency certificates would be accepted from employees. Students in secondary school went to mathematics classes where the Basic proficiency lessons were taught, but merely to comply with school regulations. No mathematics was being learned. This was a silent protest from and by students.

Parents also supported their children because firstly, the entrance fee for the Basic Proficiency examination was identical to that for the general proficiency; secondly the certificate had no value for workplace or institutes of higher learning. It had no currency. Soon the Caribbean examination Council as the Examination Board took the decision to abandon the examination entirely since it was not a profitable venture. Hence only the General Proficiency Level Mathematics certificate is issued to school leavers. Since its inception the syllabus has been revised and amended as seen in Table 8.6 below:

Table 8.6: Revision Years for CSEC Mathematics Syllabus

First Published in 1977
Revised in 1981 Revised in 1985 Revised in 1992 Revised in 2001 Revised in 2008 Source; CXC 05/G/SYLL 08

8.6.1 Present Caribbean Examination Council's Board Mathematics Syllabus

1. Rationale

Mathematics as taught in Caribbean schools should be relevant to the existing and anticipated needs of Caribbean society, related to the abilities and interests of Caribbean students and aligned with the philosophy of the educational system (CXC 05/G/SYLL 08).

The syllabus seeks to provide for the needs of specific mathematical techniques in the future careers of students, for example, in agriculture and in commercial and technical fields. By the end of the normal secondary school course, students should appreciate that the various branches of mathematics are not rigidly segregated and that the approach to the solution of any problem is not necessarily unique (CXC 05/G/SYLL 08).

2. Aims

The syllabus aims to:

Help students appreciate the use of mathematics as a form of communication

Help students acquire a range of mathematical techniques and skills and to foster and maintain the awareness of the importance of accuracy

Make mathematics relevant to the interests and experiences of students by helping them to recognize mathematics in their environment

Cultivate the ability to apply mathematical knowledge to the solution of problems which are meaningful to students as citizens

Help students cultivate the ability to think logically and critically

Help students develop positive attitudes such as open-mindedness, self-reliance, persistence and a spirit of enquiry

Prepare students for the use of mathematics in further studies

Help students develop an appreciation of the wide application of mathematics and its influence in the development and advancement of civilization

Help students become increasingly aware of the unifying structure of mathematics

(CXC 05/G/SYLL 08)

3. Organization of the Syllabus

The syllabus is arranged as a set of topics and each topic is defined by its specific objectives and content. It is expected that students would be able to master the specific objectives and related content after pursuing a course in mathematics over five years of secondary schooling.

The design allows for a core which contains selected mathematical skills, knowledge and abilities necessary for any citizen in our contemporary society as well as objectives to meet the needs of those who will be:

Pursuing careers as agriculturalists, engineers, scientists, economists

Proceeding to study mathematics at an advanced level

Engaged in the business and commercial world

The Examination will also comprise an Optional section which will be defined by additional specific objectives (CXC 05/G/SYLL 08).

4. Format of the Examinations

The examination will consist of two papers: Paper 01, an objective type based on the core objectives and Paper 02, an essay or problem solving type paper based on both the Core and Optional Objectives.

Paper 01

(1hour 30 minutes)

The paper will consist of 60 multiple-choice items, sampling the core as depicted in Table 8.7:

Table 8.7: Distribution of marks among core areas of the syllabus

Sections	Number of Items
Computation	6
Number Theory	4
Consumer Arithmetic	8
Sets	4
Measurement	8
Statistics	6
Algebra	9
Relations, Function and Graphs	6
Geometry and Trigonometry	9
Total	**60**

Paper 02

(2 hours and 40 minutes)

The paper will consist of two sections

Section 1 90 marks

The section will consist of 8 compulsory structured and problem solving questions based on the core. The marks allocated on the topics are:

Table 8.8: allocation of marks according to topics

Sections	Number of Marks
Sets	5
Consumer Arithmetic and Computation	10
Measurement	10
Statistics	10
Algebra	15
Relations, Functions and Graphs	10

Geometry and Trigonometry	20
Combination question/Investigation	10
Total	**90**

Combination *question/investigation may be set on any combination of objectives in the core including Number Theory.*

Section11. 30 marks

This section will consist of 3 structured or problem-solving questions based mainly on the Optional Objectives of the syllabus. There will be one question from each of the Sections Algebra and Relations, Functions and Graphs; Measurement and geometry and Trigonometry; and Vectors and Matrices.

Candidates will be required to answer any two questions. Each question will be allocated 15 marks

The optional questions will be set as follows:

ALBEBRA and Relations, Functions and Graphs

The question in this section may be set on:

Algebra

Optional Specific objective 17 or any of the other Specific Objectives in Algebra

Relations, Functions and Graphs

Optional Specific Objectives 15, 22, 23, 24, 25 or any of the other Specific Objectives in Relations, Functions and Graphs

Measurement and Geometry and Trigonometry

The question in this section may be set on:

Measurement

Optional Specific Objectives 5, 6 or any of the other Specific Objectives in Measurement

Geometry and Trigonometry

Optional Specific Objective 20 or any of the other Specific Objectives in Geometry and Trigonometry

Vectors and Matrices

The question in this section may be set on:

Optional Specific Objectives 5, 11, 12, 13 or any of the other Specific Objectives in Vectors and Matrices

(CXC 05/G/SYLL 08)

5. Certification and Profile Dimensions

The subject will be examined for certification at the General Proficiency

In each paper, items and questions will be classified, according to the kind of cognitive demand made, as follows:

Table 8.9: Description of each of the three cognitive demands purposing the examination questions and the allocation of marks

Knowledge	*Items that require the recall of rules, procedures, definitions and facts, that is, items characterized by rote memory as well as simple computations, computation in measurements, constructions and drawings.*
Comprehension	*Items that require algorithmic thinking that involves translation from one mathematical mode to another. Use of algorithms and the application of these algorithms to familiar problem situations.*
Reasoning	*Items that require:* *Translation of non-routine problems into mathematical symbols and then choosing suitable algorithms to solve the problems* *Combination of Two or more algorithms to solve problems* *Use of an algorithm or part of an algorithm, in a reverse order, to solve problems* *The making of inferences and generalizations from given data* *Justification of results or statement* *Analysing and synthesizing*

Candidates' performance will be reported under Knowledge, Comprehension and Reasoning that are roughly defined in terms of the three types of demand (CXC 05/G/SYLL 08). Table 8.10 indicates the weighting profile used in CSEC Mathematics Examination.

Table 8.10: Weighting of Paper and Profile Dimensions

Source: (CXC 05/G/SYLL 08 pp.1-6)

Profiles	**Paper 01**	**Paper02**	**Total**
Computation	18	36	54
Comprehension	24	48	72
Reasoning	18	36	54
Total	**60**	**120**	**180**

8.7 Topics Informing the Syllabus

In this section, I present relevant excerpt from The Caribbean Examination Council's mathematics syllabus to provide readers with some knowledge of the content informing the syllabus. A detailed account of the syllabus content and all objectives associated with each topic could be accessed at the website: www.cxc.org.

- Number Theory
- Computation
- Consumer Arithmetic
- Sets
- Measurement
- Statistics
- Algebra
- Relations, Functions and Graphs
- Geometry and Trigonometry
- Vectors and Matrices (CXC 05/G/08)

Comment

Categorization of these topics under the categories of:

(i) Arithmetic

(ii) *Sets

(iii) Algebra

(iv) Geometry and Trigonometry

(v) *Matrices and vectors

Would reveal that the topics of the syllabus could be categorized as members of each one of these headings as shown in *Table 8.11*:

Table 8.11: Categorizing the Topics of the Caribbean Examination Council's Mathematics Syllabus (2010)

Syllabus	**Arithmetic**	**Algebra**	**Geometry and Trigonometry**
Caribbean Examination Council !979-Present	Number Theory Computation Consumer Arithmetic Measurement Statistics M**A**T*R**I**C**E**S	Relations Functions Graphs	No New Topics

I would argue that the content of the Caribbean examination mathematics syllabus is identical to the topics found as contents for the mathematics syllabi of:

(i) The higher Education Certificate (1949-1959).

(ii) The General Certificate Education Certificates of the London and Cambridge Universities for overseas candidates (1963-1979).

While the topics: sets matrices and vectors could be described as new components to the secondary school's mathematics programme, an examination of their contents and pedagogical operations has revealed that they are all identical to those informing the contents of the two previously mentioned syllabi spanning the period 1949-1979. Furthermore, what some of my colleagues have been calling new topics: sets, and matrices and vectors are nothing more than applications of the paradigm of algebra and arithmetic. Those of us in the mathematics classroom would recognise, that generally, solutions for *Sets* are usually written as algebraic expressions or algebraic linear equations; often it is this operation of solving equations that is being exploited in the solutions required of candidates to given problems.

Matrices relies heavily on algebraic operations, albeit that we may now be dealing with 2x2 or 3x3 dimensions; yet the operations are still embracing linear equations and the Laws for sequencing of operations associated with the Arithmetic topics. In the case of vectors, this is directly related to the Cartesian plane, using as its framework our customary X and Y axes. Then all operations associated with relations of ordered pairs, giving rise to coordinates, for example, (5, 6) provides foundation for the *position vector's* coordinates 5,6.

This is the quintessence of the operations associated with vectors. Then arithmetical algorithms of multiplication, addition, subtraction and division are introduced at various stages of the operation into the problem in achieving the desired result: same basic operations from 1949. Hence I argue that the CSEC syllabus informing lessons in the mathematics classrooms in secondary schools of Antigua and Barbuda has not introduced anything creative or innovative to the mathematics classroom or lessons to prepare students for twenty first century technological tools requirement for workplace activities; especially as it relates to the increase in technological tools and gadgets informing communications and operations in the workplace. In fact statistical data support the argument of no significant contribution being attained from the use of the Caribbean Examination Council syllabus in mathematics. These are presented in the subsequent section.

8.8 Impact of CXC Mathematics Syllabus on Students' Performances in their Annual CSEC School Leaving Mathematics Examinations

In this section I provide statistical data in Table 8.12 and Table 8.13 for the six secondary schools informing my research, to justify my claim that the CSEC mathematics examinations were not providing any significant mathematical results to appropriately prepare secondary school leavers for the job market. I also provide statistical data in Table 8.14 to show the academic qualifications of teachers involved in teaching mathematics; since subject knowledge of facilitators could directly influence the students' performances in the subject.

The objective for most teachers in the mathematics classroom in Antigua and Barbuda is to teach mathematics to students (Government of Antigua and Barbuda). The disparity in this objective comes where the question of: *why teach students mathematics*, becomes part of the equation. In this research, emerging from the responses of participants to the question: what do teachers belief their mission is in the mathematics classroom/lessons? Most participants gave the following comment for their response: "preparing students to pass an examination" (participants). The collective data from the secondary heads of mathematics departments, the data collected from Athena, and the data from the principals all provide evidence to this claim (see Chapter 6, p. 175).

Disparity arises where in Antigua and Barbuda teachers are called upon to perform two roles: (i) to teach mathematics to students, which could ultimately result in their achieving a passing grade in their school leaving mathematics examination. (ii) To appropriately prepare students who enter directly into the job market subsequent to graduation to handle the mathematics associated with the jobs at their various work places, especially with the increase in technological devices, gadgets and tools now forming part of the labour market environment. Additionally, the preparation of students for the 21st Century workforce is being impacted negatively while using the CSEC mathematics syllabus because there is no practical component. The lessons are informed by a high theoretical focus, taught by teachers in the main with very limited mathematical background (see Table 7.14 p.227). In fact, the majority of teachers teaching mathematics in the secondary schools in Antigua and Barbuda are teachers with background in other disciplines with only a small branch of mathematics embedded in their subject area. Teachers have not been trained in the art of teaching secondary school mathematics. Teachers teach as they were taught: this spans a period of some 50 years ago (1949-2009). Hence teachers are being asked to prepare students for their future jobs (2009 and beyond) where technological literacies will be vital components, with teaching strategies and tools using 1950 technology. This is a grossly unachievable demand. Because of the poor level of mathematical knowledge by teachers, students' fear for the subject, coupled with other psychological, social, economic, and political factors, the following results as it relates to passes in The CSEC annual school leaving mathematics examination from 2000-2012 provide the following statistics.

Table 8.12 Showing the National Pass Rate of Students in the Caribbean Mathematics Examination in Antigua and Barbuda

Source: CXC Statistics Booklet, Ministry of Education, Antigua and Barbuda

Year	Male &	Female %	Total %
2000	40	33	36
2001	33	36	35
2002	41	36	38
2003	47	43	44
2004	32	35	34
2005	34	30	32
2006	39	34	36
2007	42	32	37
2008	47	38	42
2009	32	29	30
2010	39	35	37
2011	31	27	29
2012	26	28	27
2013	28	26	27

Table 8.13: Yearly Percentage Passes of Six Schools in Antigua and Barbuda

Year	Phillip	Alexander	Aristotle	Macedonia	Conquistadores	Thessaloniki
2000	13	10	26	23	24	6
2001	12	17	22	20	26	10
2002	13	3	30	18	26	20
2003	8	2	42	41	29	17
2004	2	13	44	25	12	7
2005	18	31	21	15	37	20
2006	14	14	22	3	38	9
2007	31	8	17	1	22	17
2008	15	5	24	22	17	20
2009	15	3	24	10	14	21
2010	21	13	46	20	29	8
2011	12	8	17	4	23	5
2012	10	10	9	9	18	20

Table 8.14: Academic Qualifications of Mathematics Teachers from 12 Government Secondary Schools in 2012

Categories	Numbers	Percentages (%)
Trained but without Mathematical qualification	**4**	**9**
Training in the art of teaching mathematics in secondary school	**2**	**4**
Train and in possession of School mathematics	**4**	**9**
Untrained teachers with A' level Qualification	**5**	**11**
First degree not in mathematics	**20**	**44**
First degree in mathematics	**3**	**7**
Master's degree	**4**	**9**
Associate Degree	**3**	**7**
Total	**45**	**100**

Hence there are tensions between mathematics taught in lessons in schools and the mathematics students are expected to use in their future workplaces, taking into consideration the increase in technological tools informing the local job market. I now examine the tensions and suggest reasons for their origin.

8.9 Tensions between School Mathematics and Workplace Mathematics

In this section I present argument for the analysis of the main research question*: given the increase in technological tools in the labour market in Antigua and Barbuda, what are the tensions between teaching school mathematics and preparing young people for the mathematics they will experience in the workplace?*

In Chapter 8 the analysis of the data provided suggestions for the nature of workplace mathematics and the probable benefits brought to bear on mathematical operations in the job market by the newly employed. Immediately the tensions associated with teaching secondary school mathematics and the use of mathematics in the workplace were evident. The data suggested that the characteristic and component of workplace mathematics were different to those of school mathematics. Differences were associated with the knowledge that in school classrooms students were using mathematics for a pre-constructed, fabricated problem and asked to use a prescribed, taught and rote memorized mathematical algorithm to arrive at a solution. However in the real world employees were asked to think on their feet, using mathematical principles that should provide a solution to the problem.

In this chapter, suggestions have been offered for the Rationale, Aims, Content, Organization of the Syllabus, and Format of the Examination (CXC 05/G/SYLL 08). The General Proficiency Level Syllabus, has been categorised as a syllabus designated primarily for preparation of students following the academic/tertiary trajectory and not for the preparation of students entering the job market (Caribbean Examination Council Examination Board, 08). The nature of the mathematics being taught in secondary schools in Antigua and Barbuda is therefore in contravention of the mathematics that should be informing workplace activities; although one knows that there is no physical transfer of secondary school mathematics knowledge to the workplace (Evans, 2010). What is at stake here is that the mathematics knowledge base of employees has no practical component to it. The discussion advanced by the Caribbean Examination

Council in its Rationale section of the mathematics syllabus, provides the following information for the expectation of the role of school mathematics lessons. A summary of this information now forms the content for Table 8.15.

Table 8.15: Benefits [that should be] Accruing to Students from Secondary Schools' Mathematics Programme using CSEC Mathematics Syllabus

Characteristics	**Purposes**
Basic computational skills (Add, Mult, Div, Sub,)	Use mentally to solve every day problems.
Importance of accuracy in Computation.	Foundation for deductions and decisions based on the results.
Mathematical Techniques	Applied in a variety of situations
Range of mathematical Techniques	To accommodate different levels of ability
Use mathematics in many forms of decision making	Used for shopping, budgeting paying bills and for achievement of personal goals, critically evaluating advertisement, taxation, investing, commercial activities, banking, working with and using current technologies, measurements and understanding data in the media
Improving efficiency and skills in these matters (CXC 05/G/Syll. 08).	Beneficial to the community as well as to the individuals (CXC 05/G/Syll. 08)

Although the following claims have been made by the Caribbean Examination Council Board members, many teachers in the Antigua and Barbuda classrooms have failed to make this connection for students between classroom lessons and the purpose for teaching of specific topics on the syllabus. Hence students often entered the job market with no knowledge of the role mathematics topics played in their working life. In this research most of the participants were also members of this school of thought. In their view, mathematics is a subject on the school's timetable. At the end of their school life, the knowledge resides within the domain of the school environment. Hence the challenge for mathematics teachers of the 21st Century and beyond is to ensure that the utilitarian value of mathematics is made known to students. Presently there are gaps in this knowledge.

8.10 Summary

In this chapter I present suggestions to the research question. I argue that with the recent increase in technological tools, there are gaps and tensions in teaching mathematics in classrooms to appropriately prepare students for mathematics that they could be asked to handle, in daily routines at their workplaces of the future. Several sources were used as data to provide empirical evidence to support my claims. Additionally, I suggest areas in the system in need of remedial measures. I also solicit the views of other mathematics educators and researchers in the field to bring a diverse view to the debate. In the next chapter, I present the findings and discuss their significance and implications for mathematics programmes in the future. I also make suggestions to policy makers using the findings from this research, to improve mathematics education in the twin island state of Antigua and Barbuda.

Chapter 9 - Discussion of Findings

9.1 Overview

In this chapter I offer a summary of my findings and suggest the significance of my research. I present the discussion from the perspectives of: (i) Policy Makers' system; (ii) school's activity system; (iii) workplace systems; (iv) significance of findings; (v) contribution to knowledge and (vi) researcher's reflection.

9.2 Introduction

This research was undertaken to secure strategies to address the problem facing mathematics teachers and students in Antigua and Barbuda; traditional methods are not producing the desired outcomes. As the Mathematics Officer in Antigua and Barbuda and now a researcher, I know it is time to seek more innovative and effective methods of teaching and learning in the subject. My actions also originate from the fact that some students complain to me that they cannot get more practical mathematical knowledge in school. They cannot apply what mathematical knowledge they have learned in school to their reality. Others have lost interest since the purpose of taking mathematics as a subject is seemingly just to pass an examination, seldom paying any attention to their future careers.

These phenomena stimulated me to explore the real reasons for these problems. It is one of the most significant decisions taken by me, since everything I encounter has given me new insight into how I could address the problems.

9.3 Policy Makers

This research exercise shows that research is a powerful tool for construction of information to inform my practice. My suggestion is that research should be a permanent fixture in the education system of Antigua and Barbuda. This research demonstrates not only that the tools provided by policy makers are inappropriate for a task of appropriately preparing school leavers for the workplace but also brings to the forefront the questions educators need to ask: what does controlling an education system entails? Are the policies clear to all the actors in the system?

My suggestion is that one should be seeking to uphold the principles and code of ethics governing the professional organisation. I would argue that there could be no plausible reason for any one in charge of an education system, seeking to hire qualified employees to teach mathematics, to believe that hiring individuals with neither background nor knowledge of the subject would be an asset whilst teaching lessons to appropriately prepare school leavers to handle mathematics in the job market.

Therefore in '2009 at teachers training where we had a lot of failures in mathematics' (Muriel) …… this was a problem created by the system. 'In order to stem that kind of problem, the Joint Board of teacher education had a meeting in December 2008… what they are saying unless teachers have the core subject areas…..we should not employ them' (Muriel). We as educators cannot afford to sacrifice quality for numbers. Hence a shortage of mathematics teachers in the system needs alternative solutions to fill this gap rather than hiring of inappropriate individuals. The effect of putting unqualified teachers into classrooms will impact the system negatively for years.

Like Friedman (1973) I argue that the education process in Antigua and Barbuda needs successful planners – people who show skill in management. It should not have taken attendance at a meeting of educators for any policymaker to know that individuals hired to teach at a particular level should have a higher standard of qualification than the students they are teaching, since possession of content knowledgeable by the employee is an essential requirement.

The fact that it was only after attendance at this meeting that such a policy was enacted warrants my questioning the competence and the managerial skills of personals directing education in Antigua and Barbuda. As professionals responsible for moulding young lives, our actions should exemplify that the professionalism governing the selection of persons to perform an effective role in the education system is without blemish.

One of the qualities associated with the professionals' role is the ability to create artefacts that are shaped by both the requirements of a task environment and by materials whose properties constrain the creator's ability to respond to requirements (*Wedege, 2011)*

Wedege (2011, p.4) introduces yet an alternative definition which she finds as a broad one from Wartosky (1979, p. xiii) artefacts are*:*

> *anything which human beings create by the transformation of nature and of themselves: thus, also language, forms of social organization and interaction, techniques of production, skills.*

Additionally, it is important for us in the teaching profession in Antigua and Barbuda to realize that a profession not only has a practice but also a theory of action in which that practices can become reproducible, valid technique *(Argyrisa & Schon, 1974).*

Hence my claim is, with unqualified persons hired to teach mathematics this was a disaster waiting to surface. Indeed this is one of the suggestions emerging from this research; here is a demonstration that research could show what is possible, what looks promising and what needs changing; simultaneously research could provide suggestions for the proposed corrective measures. That is why I am suggesting that research should become an integral part of the education process in the future.

In Antigua and Barbuda we are adept at expressing opinions, but in educational matters these opinions must be founded and based on evidence from research.

Arguably, research would provide information to indicate that in each profession there is an artificial environment that includes: formal, structured interactions among professionals, rules governing procedures to be followed by professionals, sharp role differentiation, spelling out what is expected of professionals; the breakdown of activities into component parts that are standardized, uniform and measurable; and the control of environment so that variables can be altered in limited and sequential ways. The applied theory of the profession spells out, for the range of professional situations and the outputs that can be expected after certain actions are invoked (Argyris and Shon, 1974).

In this research I am seeking to analyse the notion of structuring resources and their role in shaping 'mathematical activity and more broadly to add to our understanding of mathematical epistemologies in workplace settings' (Pozzi, Noss and Hoyles, 1998, p.105). As Pozzi et al. (1998, p.105) argue:

> *The idea that people think and act within socio-cultural contexts which are mediated by cultural tools have become an important theoretical framework with which to think about mathematical activity. The work of Vygotsky, Luria and Leont'ev, indeed the entire corpus of work on activity theory, offer compelling evidence that individual and social acts of problem solving are contingent upon structuring of resources, including a range of artefacts such as notational systems, physical and computational tools, and work protocols.*

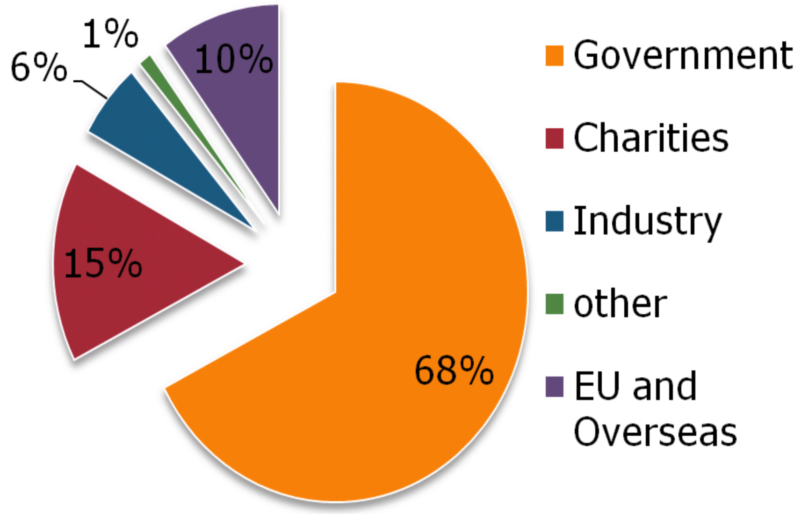
Hence educational practice in Antigua and Barbuda needs to be evidence–based and guided by research. Too many educational policies are founded upon opinions. There has to be analysis and not opinions. When that analysis is informed by research it has to be systematic. This should be practised in our construction of educational policies to avoid any reoccurrence of this situation of sending unqualified persons to teach classroom subjects in future educational practices (Gahamanyi, 2010; Azizi and Gavazi, 2008). We should be looking to use the artefacts created in our working environment since these are crystallised operations (Leont'ev, 1978), 'borne out of needs within a given set of social practices and in turn playing their part in shaping and restructuring future practices' (Pozzi et al., 1998, p.105). Research should become an integral part of our educational practices in Antigua and Barbuda, since '*every* community of educators regardless of field or specialization, can benefit from being well informed about current research findings' (National Council of Teachers of Mathematics, 2011, p.1). In the UK as demonstrated in Figure 9.1 research is an integral part of academic practices.

Figure 9: Finance allocated to research exercises in the United Kingdom

68% of total research funding in the UK originated from the Government (H.M. Treasury)

Largest Source of Government Revenue is **Income tax**

Thus the bulk of research is indirectly funded by the **PUBLIC**



Percentage of Research Funding originating from various sources

Chapter seven dealt with the negative impact of the actions of sending unqualified persons to teach classroom lessons. Equally of concern should be a precise knowledge of the educational goals and the role of the teachers while using the curriculum. There is a big gap between goal and reality in mathematics lessons taught in classrooms. This dichotomy is created where despite saying that one of the functions of the education system is to provide citizens for the labour market, teachers are given an examination orientated curriculum to perform the job.

In chapter seven the negative effect of this practice was presented. However, because my analysis of the school's activity system had assessment as its main focus, I offer more suggestions of the consequences from employing an examination oriented curriculum to allegedly prepare school leavers for the workplace.

First, there could have been no preparation of students for the work place because of inherent characteristics of an examination oriented curriculum. For example, whereas examination systems are known to interact positively and negatively with curriculum development, I would argue that in Antigua and Barbuda the negativity has far outweighed the positive attributes. Hence instead of characteristics to declare:

> *The curriculum development is perceived as generally beneficial; teachers are motivated to accept the changes and are not overburdened; the examination is valid and reliable and does not exert undue influence on teaching method; there is good articulation between the curriculum development and examinations' (anon.)*

Seemingly in Antigua and Barbuda this is the scenario*:*

> *Reduced time available for delivering the (increased) curriculum;*
>
> *Reduced subject choice for individuals (mathematics compulsory time tabled subject);*
>
> *Increased alienation of low achievers, unless they are specifically catered for;*
>
> *Increased uniformity/conformity (example, stifling of local curriculum initiatives);*
>
> *Increased emphasis on the easily measured aspects of learning at the expense of the more qualitative and social aspects of learning; increased control over the curriculum by the demand of the examination (DeLuca, 1994, p.13).*

Additional negative impact can be classified as:

> *High staked examinations; they tend to encourage teaching to the test to stress theoretical aspects of the curriculum more than practical or process-based learning. They have a tendency to encourage out-dated teaching methodologies such as rote-learning and memorisation rather than engaging pupils in a more analytical and problem solving approach (DeLuca, 1994, p.123).*

What presently policy makers are unconsciously demanding of teachers, is preparation of students for the workplace as a hidden curriculum agenda; equally as making preparation of students for an examination a transparent goal. The transparency came where teachers' competence in the subject is judged by the number of students gaining a pass in the final end of year Caribbean Examination Council's certificate school leaving exams. This is not good educational policy. There has to be 'precision in thinking and precision in explanation' (Fisher) of one's educational goal. As claimed by Nicols (2002, p.289):

> *Taught in ways that tend to focus on the abstraction of mathematical content from problem contexts, many students of mathematics are left wondering "what's mathematics good for?" As these students become intending teachers the question remains. Prospective teachers wonder how to make the study of mathematics engaging, inviting, and meaningful for their own future students.*

This is the cry (what strategies should I use?) I hear coming from the mathematics teachers in Antigua and Barbuda.

Seeking the appropriate suggestions to close this gap has energized my indomitable will to ensure that there is sufficient information from this research to begin to address this question and to narrow the gap to a gaping crater created by this question. Several scholars in the field of workplace mathematics have inspired my mission.

Therefore I have linked my research to the work of researchers in the field to include: (Wake and Williams, (2001); Williams and Wake (2007); Wake and Williams (2005); Wake, (2011); Williams (2009); Evans (2001); Evans (2009); Bakker (2010); Hoyle , Noss, Kent, Evans and Bakker (2010); Zevenbergen, (2010); Wedege, (2011); Threlfall, (2007); Straesser, (2007)and Bessot and Ridgeway (2000): Naresh, (2009; Gahamanyi (2010), Azizi and Gavazi (2008), Straesser, Pozzi, Noss and Hoyles, (1998); Masingila (1993).

In general principles of educational matters Ball (2003), Thames (2006) and Day (2009*)* are the researchers with whose work this research has been linked. Located in their work is suggestion for the question what are the professional attributes required by employees to become a teacher?

In the case of my theoretical underpinning and framework I situate the research in the work of Engeström (2001) (CHAT) with support from Daniels (2009), Avis (2007), Jonassen and Harness (2006). The CHAT tool appeared to be a fit for purpose in addressing my research questions. These were questions seeking possible suggestions to improve learning and teaching of [mathematics].

In offering suggestions which could be beneficial to the Antigua and Barbuda mathematics situation I draw on the work of Noss (1998) who writes that it is difficult to understand a mathematical idea until it is used and difficult to use a mathematical idea until it is understood. Additionally, Nicols' (2002) suggestion that 'providing beginning teachers with opportunities to experience workplace settings in order that they might contextualize their own academic understanding of mathematics seems promising' (Nicols, 2002, p.304) for future classroom mathematics lessons. I am suggesting that the practice of sending untrained teachers into classrooms will form part of the literature for the envisage change.

However, from other literature, I know that merely making visiting workplace part of the initiation process for new teachers is not enough since 'prospective teachers need support in uncovering and in making visible mathematical ideas and structures. They need support in learning to see social and work activities mathematically and pedagogically' (Nicols, 2002, p.304). Thus these suggestions proffered by Nicols (2002) should form part of the reformulation process:

> *One way could be through education to and discussion of the difficulty (Nicols 2002, p.304)*
>
> *Second way might be through broadened vision of what counts as numeracy. The term numeracy has its roots in connection with number, with a focus on numeral and symbolic computation; conceptual and procedural aspects of measurement' (Nicols, 2002, p.305). As Noss, Hoyles and Pozzi (2000, p.18) note attempting crude behavioural classifications based only on mathematics of school curricula fails to evoke the authentic details of real work practices.*

Therefore:

> *Third support needed in drawing upon their own experiences outside of school as a context for understanding mathematics in work (Nicols, 2002, p.305).*

In my future practice I will be leading the way as the change agent and ensuring that teacher support is a part of our educational process. Additionally my practice will be informed by research based evidence. One goal of teacher education is to provide opportunities for prospective teachers to develop and use their understandings of content to help their students (Ball, 2000). This research exercise has taught me that previous work experience using mathematics as well as academic understandings of content is not enough to use as knowledge for teaching (Ball, 2010; Thames, 2006).

Consequently, the foundation for future professional competence seems to be the capacity to learn to learn (Schein, 1972). As claimed by Argyris and Schon, (1974, p.157):

> *This requires developing one's own continuing theory of practice under real-time conditions. It means that the professional should learn to develop micro-theories of action that, when organised into a pattern, represent an effective theory of practice.*
>
> *The professional must also be able to act according to his/her micro-theories of action and reflect on his actions, Reflexivity relating them to the governing variables implicit in his behaviour and determining the impact of his behaviour on the behavioural world, on learning and on effectiveness*

9.3.1 Implication of Findings: Schools' Activity system

The analysis from the Teachers' system could be summed up by this phrase *lack of competences*: both as a general teacher, and as a Mathematics Teacher.

Drawing on the work of Wedege (2011, pp.3-4), by definition:

> *Competences are workers' capacities (cognitive, affective, and social) for acting effectively, critically and constructively in the workplace'. On the contrary, vocational qualifications are the knowledge, skills and personal qualities required to handle technique and work organisation in a work function, for example, formal mathematical ideas and techniques.*

My discussion for this section is associated with Wedeges' (2011) debate on the third aspect of the role of technology in the workplace.

In this dimension, two meanings of workplace knowledge are found: (i) 'knowledge developed in the individual's working life, in human competences and (ii) knowledge required by the labour market, in vocational qualifications' (Wedege, 2011, p, 4). These are the meanings of workplace knowledge which are missing from the capacity and missing from the qualifications of classroom mathematics teachers of Antigua and

Barbuda's professional tools. Hence in accordance with Wedege's (2011) definition of working competence (p.4) with these components absent from teacher's knowledge base their ability to appropriately prepare school leavers for workplace mathematics is an unachievable mission.

This mission was impracticable since 'in a simple understanding, working competence is the ability to use one's qualification on the job' (Wedege, 2011, p, 4). Therefore because mathematics qualification is missing, teachers are without the elements that classify individuals as competent workers. Absent from their ability to perform with any sense of proficiency are effective, critical and constructive skills.

This is the case presently in the mathematics classroom of Antigua and Barbuda. Although there are teachers who possess a certificate indicating a passing grade in the CESEC Examination, one always has to remember that 'to demonstrate mathematical qualification in [teaching] mathematical concepts "taught in school" is quite different from acting competently in' (Wedge, 2011, p, 4) the role of a teacher.

As argued by Wedege (2011, p.4): 'in its basic sense of capacity to act, the term competence unites the complex mix of knowing and doing'. Competence is developing in the individual's working life. There is no means of acquiring pre-defined competence. Therefore, while the context used to determine qualification is the general work organisation and technique in the labour market technology or within a particular trade or profession, there are no competences in and of them, although there are competent people. However competence is developed in the individual's working life.

Hence unlike the situation where the worker has or acquires a vocational qualification there is no opportunity for her or for him to acquire pre-defined competence (Wedege, 2011). Therefore it is in the training sessions in the practice of teaching mathematics and in training to become a teacher that teachers should have acquired the skills of professional mathematics teachers. Teachers sent to classrooms to teach without prior training was a fertile ground for the germination of incompetent teachers (see Chapter 7). This is what the Antigua and Barbuda students had to say to describe this state of teachers' classroom performances: '*teachers can't teach' (Students).*

Emerging from the data are suggestions that teachers are aware that the methods they have adapted in teaching of mathematics in the classroom are unproductive (see data from heads of mathematics departments: Aristotle and Thessaloniki). It is my argument that despite knowing this, seemingly teachers are victims of a system where to be different and to oppose known ineffective teaching strategies could be the creation of an environ to find oneself acting against the status quo, the policy makers, management and even held up to ridicule by one's peers.

Consequently I argue that classroom teachers have remained silent for too long in the face of adverse conditions and lack of support to enhance their teaching of mathematics; have preferred rather to respond to the call for more effort in the face of decreasing amounts of financial support. Therefore, in the light of a change in fortune to even worst support created by a slum in the economic activities and a down turn in economic growth created by a dwindling of earnings from the tourist market, they are still being called upon to produce maximum return having seemingly been given nothing with which to realize this goal.

It is ropbable time for teachers to be accorded the necessary support to ensure that they become competent, knowledgeable classroom mathematics teachers, providing a rich mathematics experience for students. To achieve this, the infrastructure to allow the provision of professional development is needed urgently. Hence my task in the future should be in the trajectory of *a* change agent to improve teaching and learning of mathematics in our schools while forging the link between workplace and school.

9.4 Workplace Discussion

9.4.1 Overview

In this section, I link my findings to that of researchers in the field, since all of my findings are in keeping with the research carried out by these researchers I use the following subhead to guide my discussion: (i) lessons from workplaces.

The various research sites from Antigua and Barbuda formed the foundation of my discussions. Equally as allowing me to discover the mathematics in work and to identify the mathematics hidden in black boxes at workplaces, these are the sites that allowed me to witness mathematics in different settings (Gates and Zevenbergen, 2009; Nunes, 2009 and the report from the *Advisory Committee on Mathematics Education* (ACME, 2011) in workplaces in the real world.

9.4.2 Lessons from Workplaces

Application for a job in the labour market generally emphasises the importance of having a pass and a CESEC certificate in mathematics. However, I would argue that the importance of the subject is merely as a passport for entrance into the workplace, rather than its utility value. Seemingly, this is the only purpose for mathematics in the labour force perceived by classroom teachers and society.

Alternative values and uses of mathematics were for purposes of higher education to facilitate students in their career trajectory. Thus, although mathematics should have been taught to students in classrooms, as preliminary preparation for those roles in the labour force, where mathematics is a tool, this was not a part of classroom mathematics lessons in Antigua and Barbuda.

In accordance with the proposed role of the Mathematics Curriculum to the economic activities in the Antigua and Barbuda society, it was important to keep in focus one of the main function of schools, as one of preparation of school-leavers for the workplace (Education Act, 2008, Antigua and Barbuda). My research is specifically concerned with the *nature* of the preparation students are given in anticipation of their ability to handle the mathematics in the job market. Thus the mathematical needs specifically associated with work at each of my designated work sites should have been aligned to the curriculum's content to ensure appropriate preparation of school leavers for these sites.

From a strictly educational point of view:

> *Socio-cultural approaches highlights just how far workplace mathematics differs from that taught in school, and underlines the extent to which it often involves little use of formal approaches, while 'informal methods' limited by and adapted to the goals and conditions of work are far more prevalent (Steffano, Pozzio, Noss and Hoyles, 1998, p.106).*

A central concept is that of structuring resources, as raised in the work of Lave (1988) and others in their study of shoppers' best-buy strategies. In my research the question of structuring of resources is also a central issue since in enterprises profit is the main goal of operating a business. Like Lave (1998) one of the first differences I observed was that in acquisition of mathematical solutions no systematic algorithm was required since only results were necessary. Additionally, the mathematics was embedded in the task being performed. It is apparent to me that:

> *In workplaces there are certain kinds of situations which evoke mathematical knowledge, but that, in common with Lave (1988) and others, [I] could not simply characterise them by presence or absence of a specific set of mathematical signs and conventions. Rather the key idea is mathematisation between resources, activities and settings as they are operationalised to achieve a particular goal at work (Pozzi et al., 1998, p.118).*

By *mathematisation* I am thinking of complex set of relations, including mathematical relations (Oxford Dictionary, 2006). The process of mathematisation does offer educational possibilities which 'is less constrained than school mathematics by curricula and examinations (Pozzi et al., 1998, p.118). An alternative view of the same notion by Forman and Steen (1995) claim that 'mathematical activity [in the workplace] can be viewed as a rich source of higher-order thinking based on lower-order mathematics' (p.221).

Pozzi et al. (1998) has demonstrated from their study that mathematics:

> *Enters practices in a rich variety of ways and it is a mistake to avoid the complexity of a situation by employing standard criteria to capture its visible arithmetic and then teach it (p.118) a further view claim by the researchers is that 'if one restricted the notion of mathematics to elementary topics, one will find plenty of occurrences, but elementary instruction in these will not necessarily be applied and certainly will not cover all the necessary knowledge that is actually relevant to practice. There is simply an insufficiently rich intersection between simple computations and the means by which judgements are made in the work place (Pozzi et al., 1998, p.118).*

These are claims I share with the researchers since in executing my research these identical observations are a part of my findings.

Custom's Department

In the divisions comprising this unitary workplace, the work in general to include the mathematics, is performed in application of procedural matters. However, although the mathematics is the basic arithmetical consumer arithmetic of percentages, discounts, taxes and four arithmetical operations, crucial to the departments' success of their missions is the ability of the employees to follow with precision the ordering and the sequencing in which actions are performed, mathematical operations employed and an estimation on the part of the employees of numbers that should be solutions to calculated problems.

In this worksite judgement is important and therefore the newly employed, although able to handle the mathematics in work, would function mainly in roles of apprenticeship, where there is supervision from senior personnel. Hence the routine in the job and the role of mathematics are not the paramount focus in this workplace. Rather the main focus is employees' ability to follow procedures systematically. Human relationship, team work and the ontological properties of employees are the attributes dominating work in each department.

While the newly employed is required to function in the role of an apprenticeship, there are other technological skills required, since this is one of the governments' fully computerised departments. It was transformed into a fully computerised entity by Technological Technicians from the Asian continent: India. This is a demonstration of importation of Labourers to deal with high technological literacies in the economy since this is lacking among employees in general and specifically, among most school leavers. Hence because the competent worker is missing despite the presence of the machine and technique and the work organisation, components of technological trajectory, the technology would have been useless in this workplace. The competent human factor is quintessential to any technological operation.

Investigation of technology in the workplace reveals that mathematics is embedded in three dynamically interrelated dimensions: (i) machinery and technique; (ii) work organisation and (iii) workers' competences and vocational qualifications (Wedege, 2011). It is important at this juncture to offer definitions for several terms that will form part of future technological discussions. These are definitions provided by Wedege (2011, p.3). Thus*:*

> *Technique is used in a broad sense to include not only tools, machines and technical equipment, but also includes cultural techniques (example communication and time management), and techniques for deliberate structuring of the working process (Wedege, 2011, p.3).*
>
> *Work organisation is used to designate the way in which tasks, functions, responsibility, and competence are structured in the workplace in order to achieve a specific goal (Wedege, 2011, p.3).*
>
> *Human Competences are workers' capacities (cognitive, affective, and social) for acting effectively, critically and constructively in the workplace (Wedege, 2011, p.3).*
>
> *Vocational qualification are the knowledge, skills, and personal qualities required to handle technique and work organization in a work function; for example formal mathematical ideas and techniques (Wedege, 2011, p.4)*

A second and central point:

> *In this understanding of technology is that new information technology [IT] – or any other machinery or techniques – does not bring about change or development by itself. Competent workers qualified to handle the particular IT as well as appropriate work organisation are also needed (Wedege, 2011, p.4).*

It was from this perspective that this researcher argues that 'any workplace is technological in that it combines the three dimensions' (Wedege, 2011, p.4). This perspective of defining technology opposes other views which imply that the 'term technological is reserve for IT pervasive (spreading widely throughout a region) workplaces as in the terminology of Triantafillou and Potari's (2010) study of a telecommunication organization and in the definition of technological literacies put forward by Hoyles et al. (2010)' (Wedege, 2011, p.4):

> *Artefacts are anything which human beings create by transformation of nature and of themselves: thus, also language forms of social organization and interaction, techniques of production and skills (Wartofsky, 1979, p.xiii).*

As claimed by Wedege (2011, p.4):

> *The understanding of technology presented by these definitions allows for the manifestation of three types of mathematics: (i) containing artefacts embedded in the dimensions of technique; (ii) work organisation (iii) human competence.*

In my research all three categories were observed. For example, the software programmes in use in workplaces make handling of the technological requirement skills for the newly employed achievable. Additionally, although school leavers are expected to understand the operations behind the screens of the computers, in their daily routines, only operations are required to achieve the mathematical solution desired in carrying out their workplace mathematical routines, since the mathematical algorithms are hidden in the black boxes created by computer soft wares. Because of team work among employees there is checking of colleague's work at each point of an activity engaging employees. Consensus of opinions is one of the measures used to guarantee success of a mission. Computers and handheld calculators are the most frequently used technological tools in this workplace.

The Markets

In the markets, the mathematics employed is the consumer Arithmetic branch of bills, conversion of foreign exchange to the $E.C. Eastern Caribbean currency. However in the vegetable market, the sensory organs, the eyes play a key role in the mathematics employed in work. This occurs where the *activity* of weighing of agricultural provisions has been transformed into *operations*. Years of performing the same activity, accounted for its status of an operation. Hence Vendors are able to use vision to attain the correct weight for goods ordered by customers (see DVD from Chapter 8). Pens, paper and mental arithmetic are the tools used to provide the correct bills.

In the **meat market**, skills in using the different tools associated with butchering are additional requirements. The mathematics embedded in this job are logic and reasoning, estimation, Geometry (for example - angle at which some incisions were made), consumer arithmetic and statistical averages (example which market day required more products (Mode, mean); most popular requested part of meat by customers.

In the **craft market,** creative art and sewing are the dominant activities. The mathematics associated with sewing is not only measurement but division; additionally some of the four mathematical operations are embedded in work. Judgement is critical for the success of the mission. Elsewhere, geometry in terms of shape, consumer arithmetic, statistical averages, estimation, reasoning and logics are also embedded in the work.

Noticeable in the markets is that the employers are mostly from the elderly, senior citizenry. School leavers are hardly to be seen in these workplaces. These are the indigenous industries of the nation. They are for the most part filled by senior citizens from the lowest rung of the educational ladder. Yet, these are the members of the society leading the way and demonstrating how best to utilise a country's natural resources (land, sea, sun and sand) to include climatic conditions, to create the industries of national significance to the economy. A country that cannot feed its population would always find itself at the wrong end of the economic global landscape. These are the people with the capacity in their activities to expand economic growth in the country (See Chapter 8).

This is one of the worksites showing the disconnection between the education process and the economic activities in the country. School leavers employed in this activity are generally involved in the continuation or the expansion of a family's business. Yet these are the sectors that the soon to become dominant economic giant (China) is taking to build its economy: small industries contribute 75% labour for the workforce and the aggregate contribution to GDP is 64 %. (see Goel et. al., 2006). Hence in Antigua and Barbuda, the Mathematics Curriculum is not contributing significantly to national development from this perspective.

Island Services

With its several departments all demonstrating a different branch of the mathematics discipline, this is the ideal worksite for teachers and students to visit. I would like to experience and to see how many of the mathematics in work teachers would be able to identify. In my research this is where the 'pepper pot' made from mathematical ingredients is to be found. At this worksite there are mathematics informing professions of:

- Mechanics: (The Garage workshop)
- Construction: (Employees engaged in building of a concrete wall)
- The Gardner's**:** (Horticultural Branch of Agriculture: Gardens, trees, Green Houses and Nurseries)
- Engineers: (Osmosis plant, electrical power plants Sewage plants and the Desalinating plant)
- Pilots and Marine Vessel or Captains: sea vessels, navigation: (sea and air)
- Teachers: to identify in work: (part shop, all of the above; measurement, fractions, consumer arithmetic)
- Builders or Masons - (Building the wall)

There are also black boxes (Williams and Wake, 2007) in which mathematical processes are embedded: navigational instruments at the control of the Ferry, in the power houses, tools used by construction employees in purchasing correct weight of aggregates.

Hence, in this work site several different settings for various branches of mathematics were observed: ratio and proportion (wall building); measurement; temperature, geometry; trigonometry; algebra; time, estimation, arithmetical calculation; distance, time and speed. At this worksite, it is precision (judgement) in performance that was the operative mode required by employees.

Here various aspects of measurement are an integral part of work: mechanic shop, garage, building a wall, height of water in the tanks; in the length of time between intervals before changing certain operations in the power house. Measurement in distances travelled and the amount of gas or diesel needed for the engines to run. Additionally, at this plant, I observed the interconnection between the different branches of mathematics in a single operation. The mathematics is always embedded in the task. Hence different forms of measurement are the main mathematics associated with this utility plant.

Hotels

In these workplaces there is nothing basic or unskilled in the roles associated with the jobs in the hotel industry. In fact these are the worksites with manifestation of techno-logical literacies at work. At every juncture the employee is called upon to use mind, body and soul to make pertinent and critical judgement while in the execution of a task in work. Mathematics is associated with every activity for all the categories of employees in these work places.

Chefs

The data from these professionals provided my examples of differences in teaching strategies that existed between taught concept in the classroom and taught concepts in the workplace. In the classroom the mathematical concept is abstract and had not been linked to students' personal experiences. In the work place for example, (in Chapter 8,) the association used in teaching the *US's Measurement of Units per metric Tables* demonstrated the scenario of linkage between the taught concept of mathematics and students' personal experiences.

Here I also learned the importance of the arithmetical operation of *division* in furnishing the number for the meals that would be required to adequately serve all the guests in the hotel at meal times. The solution is embedded in a mathematical equation of *Poundage of Food divided by number of guest in the house*. The inability of chefs to apply the right algorithm to achieve the correct result could incur wastage. This incorrect mathematical calculation could equally result in a negative effect upon the hotel's profit.

Hence newly employed entering the division lacking in the basic and fundamental mathematical concepts for *division* could be responsible for a decline in the hotel's profit. Although the mathematics required in this workplace has been described as basic, during this data collection exercise, I learned that some newly employed school leavers are lacking in even basic mathematical principles. To fill this gap in knowledge, generally, a time span of between six months and one year is required.

I can therefore understand why in a competitive environment, on-the-job training for employees lacking in necessary technological skills will be a thing of the past. Every business enterprise exists chiefly to make a profit. When knowledge was the commodity being marketed then this on-the-job training would be counterproductive. Knowledge was not a scarce commodity and companies had to be in the vanguard with marketing of their products in this competitive environment.

Laundry Department

Many Antiguans and Barbudans would be surprised to know the amount of mathematics that was embedded in this work. From beginning to end, the work is based upon mathematical principles. Prior to this research, not even the staff in the department had knowledge of the mathematics that they were using every day while carrying out their roles. This mathematics is manifested not by a paper and pen algorithmic operation but rather in activities governing the completion of their work.

This revelation demonstrates that while using black boxes as tools, for example, washing machines, operating switches and iron machines, it is not only intuitive knowledge that is at work (although these are necessary to ensure engagement of the correct mathematical operations); rather it was the mathematical principles that were central to the success of their missions.

For example, the choice of using the right machine depended upon the *weight* of the clothes. Also, the type of linen in the laundry would require a different branch of mathematics, since temperature was involved. Yet mathematics was at work when the decision had to be made for the volume of water that would be required to operate the machine with the specific load of clothes to be laundered. Getting the right detergent and using the correct amount of detergents were also areas of mathematical operations involving estimations reasoning and logic and some consumer arithmetic; so too where the operation was setting the *timer* of the machines. All of these actions were founded upon mathematical principles.

Pressing the appropriate buttons accomplishes the missions. However although the mathematics employed in this departments is of the technological literacies domain, the human element is still needed as check and balance mechanisms to ensure correct buttons are employed. All these activities could be executed successfully by newly employed once the correct knowledge of how to operate the tools is acquired. Hence the technology in the workplace is still heavily dependent upon the competent knowledge and skills of the human element for its success.

In general, I learned that most workplaces are engaged specifically with on-the-job training to ensure that workers were representing the organisations' brand of its product, and their specific culture. Thus it was an entirely new perspective to learning in classrooms. In most cases the newly employed had adapted well to these new strategies of learning within the context of their work.

In the workplace learning is by association. Also the sense organs, especially vision and smell, play a major role in the mastery of one's work. Further, since most activities are fixed daily routines, they are soon learned by the employees and thus transformed to operations. Still in the work place school's mathematics algorithm associated with a problem is not a requirement; employees are only required to use mathematical results. Where conversions are part of the mathematics in work, generally, the results required by the employees are signposted on charts decorating the walls of the workplaces.

Hence it is possible for the newly employed with a love and a passion for their work to develop and advance in this working environment whilst learning the mathematics associated with their workplaces. Black boxes are a major feature in enhancing the learning of this workplace mathematics: at times these involved actions of pushing of a button, pulling of a string and the turning clockwise or anticlockwise of a devise. Checks and balances and team work allowed for the corrective measures whenever mistakes were encountered.

In concluding I would argue that the mathematical processes underpinning the chefs' work and the activities in the Laundry Departments' activities *to be* based more on personal knowledge and possession of skills by the individuals rather than on the employment of technological tools. These tools are complimentary to the mission being performed by the human element (employees) (Wedge, 2011). Therefore, where these knowledge and skills are missing from the knowledge base of the newly employed the result could result in a net loss for the business enterprise.

Hence, since students are not appropriately prepared for the job market, and therefore necessitating an on-the-job training period of at least six months or one to fill the knowledge gap, there is a need for a reformulation of the secondary schools' mathematics programme and additionally the need for an examination of the resources allocated to perform the task. My first claim is for the need for provision for professional training of all mathematics teachers (see Chapter 7). Second I would argue for a change in the curriculum from an examination theoretical model to one which is in keeping with requirements of technological skills for a 21st Century labour force.

This should be a curriculum 'that emphasises expected outcomes in terms of new skills and competencies that learners require in understanding, and being able to develop, mathematical models' (Wake, 2011, p.7). This curriculum therefore should allow students:

> *To explore how mathematics can be transformed to meet the needs of a range of diverse situations, with at times focusing on the coupling and at other times a focus of the development of the mathematics itself. This suggests the need for continued research and for continued development in this area of major importance to future worker expertise and adaptability* (Wake, 2011, p.7).

9.5 Reflection

9.5.1 Overview

In this section, several subtopics form the basis of the discussion. The impact of present policies on status of: (i) students in the school's environment; (ii) on the employers and (iii) possible measures needed to effect the changes.

9.5.2 Students in the School Environment

The education system of Antigua and Barbuda has a mandate to appropriately prepare students for the workplace. As I am reminded by the Minister of Education (2011) 'education is a right and not a privilege' (Statistical Digest, 2009, p.1). Many students within schools, held contrary views to the Minister's views, since some policy makers still held the view that education was a privilege and not a right.

I would argue that if we say education was a right, then students should be given a carte blanche when making their choices of subjects for their career trajectory. In some schools this was not the case. In terms of no say in choice of a subject by students the discipline of mathematics is a prime example. Students are compelled to attend classes since policy makers have made it a compulsory timetabled subject. In the days of Basic Proficiency, against students' opposition and the objection of their parents, students were placed in this stream.

Hence students are hardly allowed to make any decisions of their own. Yet, this is where students are being appropriately prepared for workplaces: environments requesting thinkers who could make inform decisions think on their feet, able to lead on matters of making judgements. However, students are denied the opportunity to develop these character traits which could have initiated the preparation for characteristics associated with workplaces.

The fact that students in the mathematics classroom do not have access to the technological tool software programme meant a further lack of preparation for the present workplaces now dominated by technological literacies. These denials did not just appear overnight. A retrospective glance to the entrance of students into formal education's would reveal that once behind the walls of the school, (whose main role is ostensibly preparation of students for living in society and specifically for role as a member of the Labour force) all democratic rights, associated with free citizens were taken away (Ridging, 1977).

Once an individual was identified (uniform) as a bona fide student of any school, even from outside the walls of the schools, some education policy makers still perceived them as citizens without the right to act as they chose. Therefore behaviours described as despicable could result in a public reprimand for the offender and aftermath consequences. Hence environments where students are prepared to become members of the labour force and part of workplace activities are controlled by seemingly strict codes of conducts, bordering in some cases on becoming draconian laws.

During the registration period, to become a member of any Government school, generally, students and their parents are asked to sign forms (contracts) pledging to abide by all rules and norms associated with the school. Registration is a time of anxiety for most parents and associates of students; it is a period when all associated with the process from the public's perspective are most vulnerable, because of their foci on getting their children registered.

Hence, at times not fully conscious of the recompense of this signature many parents and guardians would have signed contracts with schools giving permission for teachers to have the right to use undemocratic principles to invoke corrective measures. Consciousness of such an act for many came later, without a course for redress. Principals and teachers assume that they have the right to keep a tight rein and to execute institutional power over the individuals; under the banner of upholding the name of the school and of protecting the students themselves from unwholesome conducts of some school mates.

Nevertheless the experience for some students is harrowing; to other students, an experience to be thrown in the dust bin of history. For example, speaking without first raising a hand and then having to wait for that permission to speak; for others a salutation was required, using a specific format; or for others they were expected to stand when addressing the teacher. Where students expressed views contrary to those of the authorities, in some cases, these were not tolerated or frowned upon. Seemingly in the school's environment preference for mode of behaviour could be best expressed using the cliché that students were to be seen and not heard.

This is also the mode of behaviour that some Mathematics teachers demand for their classrooms. Criticality is not a part of most lessons in the Antigua and Barbuda classroom. Hence students exist in an environment of dependency upon the authorities (to include classroom teachers): told when to speak; told when to get ready for a mathematics lesson and which topic would be addressed; told when to take a break and what was the duration of that break; told when it was time for a midday meal; told where and how to socialize with their class mates. Decisions are constantly being made by an authoritative figure on their behalf, without giving them the opportunity to make a personal input.

That is why in my research, despite knowing that students legally are probably in no position to give suggestions to my research question, I was determined to give them a voice from any perspective as a mathematics student to make their contribution to my research investigation. My aim was to let them know that despite not being recipients of the overall benefit of this research, in the future there would be a complete change in how students will be taught mathematics.

Hence, I would argue that the environment, in which preparation of students for the workplace takes place, is not conducive for their appropriate preparation for workplaces. I would further argue that these classroom cultures could have been directly responsible for the lack of assertiveness in newly employed who enter the work force immediately following graduation from secondary schools.

Noise resonating from a classroom during the progress of a lesson with a teacher in attendance was frowned upon by some members of staff and some principals. For some authorities this represented the *bête noire* within the school's environment. Thus, students having been exposed to this environment for five or more years would have been outside their comfort zone to manifest desired workplace characteristics of an employee.

From a humanistic point of view, a major purpose of education is to help individual students to develop their unique features and to realize their potentials (Hamacheck, 1990). This therefore should have indicated that ‘teaching was not about telling students what they needed but rather teaching was to help students find out who they were, what they wanted’ (Chen, 2008, p.56).Therefore, in Antigua and Barbuda, for most students, making the boundary crossing to the environment of the workplace was probably not an easy feat.

9.5.3 Transition from Education to Work

In making the move from the school’s environment to that of the workplace, school leavers entering directly into the workplace could have several challenges to overcome. These challenges might begin with:

- The transitional stage;
- Attempting to incorporate teamwork mechanisms and genres as part of one’s asset for the workplace;
- Dealing with requirements of the workplace’s environment;
- The use of mathematics as a tool in accomplishing for routine activities in the workplaces of Antigua and Barbuda

Globally, School leavers in the 21st Century have been called upon to make increasing complex choices in preparation for their careers and workplace roles. However:

> *While acknowledging the changes to the social, political and economic context within which young people now live, the argument has to be predicated upon arguments to focus on changes to the nature of transition, rather than an assumption that the concept was now obsolete (Brooks, 2009, p10).*

Three significant trends in school leavers’ transitions have been identified in many parts of the world:

> *First, young people were remaining in full-time education for longer periods of time and as a consequence, entering the labour market as full-time employees at a correspondingly older age (in Brooks, 2009). In Antigua and Barbuda this was controlled by the labour code (see, Antigua and Barbuda labour Code, 2006, pp. 32–36).*

Global evidence could be seen in Western Europe, the United States and Australia, but also in Asian and Post–Communist countries (France, 2007 cited in Brooks, 2009, p.1).

> *Second, the youth labour market remains stagnant. Stagnation had its root in the early 1980s when youth employment collapsed as a reaction to a more general economic downturn. As Furlong and Carmel (2007) note, youth unemployment was typically more sensitive to economic pressures than adult employment, and thus suffers disproportionately during periods of recession. For various parts of the world this occurred at differing times: It was not experienced in Japan until the mid1990s.*

In Antigua and Barbuda it was in the middle of the 1990s, made even more severe with the passage of two hurricanes which reaped havoc on the economy, as the tourism infrastructure was severely affected: the area where youth employment was generally maximized. Today, in Antigua and Barbuda, apart from lacking the high technological literacies and skills required for the present labour force, 'structural changes to the labour market over the last part of the twentieth century have had a significant impact on the type of work that is available to school leavers in search of employment' (Brooks, 2009, p.2).

It is further my argument that:

> *We are witnessing more variation in patterns of transition, as young people increasingly 'blend' periods of education and work, moving backwards and forwards between engaging in significant elements of paid work, whilst being a full-or part-time student. Schoon et al. (2009) also demonstrated persistent inequalities across the fortunes of those with the lowest level of qualification. Indeed, they contend that as a result of the more general trend towards staying on longer in education those who leave 'early' with few or no qualifications were increasingly adversely affected by the disappearance of traditional entry- level jobs and the polarisation of the labour market (Brook, 2009, p.3).*

This argument lends credence to the findings of the World Bank Researchers' (2007) claim that the Caribbean Mathematics Curriculum's content is insignificant in preparing school leavers for the labour force. It further supports my argument that the Third form Mathematics Certificate offered by The Caribbean Examination Council's Examination Board will have no currency or economic value in the labour markets of the future. Holders of this certificate will be marginalised in the present job market and in the job markets of the future. 'Similar arguments are advanced by Dwyer and Wyn (2001) in their analysis of young people's transitions to employment within the Australian labour Market' (Furlong and Carmel, 2007, p.29).

In the Antigua and Barbuda society where the unemployment figure is 30%, school leavers from working class backgrounds are over-represented among this number. As claimed by Brooks (2009, p.3.):

> *These trends in school leavers' transition from education to work are inextricably related to wider economic changes globally. The changing structure of the labour market, periods of recession and the increasing dominance of the so-called 'knowledge economy' has all had considerable impact on the experiences of school leavers coming towards the end of full education.*

In Europe:

> *Youth researchers have argued that school leavers' transitions from education to work have been altered, not only by the changing economic structures around the globe, but also by the considerable shifts in the political environment that occurred in the last couple of decades of the twentieth century –namely the demise of the communist regimes in central and Eastern Europe and the drive towards further European integration across the continent (Brooks, 2009, p.4).*

In reflecting on changes witnessed in the last few decades of the twentieth century, Chisholm (2006, p.15) notes:

> *Transitions to the labour market were taking place not only later, but also in more differentiated and gradual ways as young people mixed study and work in a combination between practical economic necessity, tactical career planning, and personal choices.*

Finally the third pattern informing transition globally of young people from education to work is that:

> *Alongside of the extension of full-time education, one is witnessing the emergence of what some researchers have called the 'training sate as a major pathway for school leavers since the 1980s (Mizen, 2004, cited in Brooks, 2009, p.3).*

This was the genesis and philosophy underpinning the Government's Youth Skills programme in the early 1980s in Antigua and Barbuda. Further, arguably:

Offering more extensive training packages to young people as they left school had been one way in which national governments have had tried to manage unemployment and skills shortages' (Chisholm 2006; Furlong and Cartmel, 2007 cited in Brooks, 2009, p.3).

In the future this avenue of on-the-job training will no longer be available.

With the economy of Antigua and Barbuda founded on tourism, any economic downturn in the global market would have had a negative impact on economic activities in the country. Today the philosophy underpinning the former Youth Skills Institution has changed. It is a philosophy that I am not able to address presently. However, this inappropriate preparation of students for the job market indicates that there was need for a reformulation of the entire education policy.

For while the Caribbean Examination Council's role has created a closer unified voice for the people of the Caribbean, there can be nothing significant or profitable about this measure if the main function of appropriately preparing school leavers for the workplace is inadequate. So while Caribbean Governments, to include the Antiguan and Barbuda Government perceived this as a cost cutting mission, in the long run the net gain could be more detrimental to economic activities. In its present state it only creates labourers that are unemployable; because of the lack of the required skills for the job market. There is need for a change in our education programme since the transition from school to work, based on the evidence from this research is in crisis.

9.6 Significance of the Findings

In this section I identify the significance of my research to (a) the research community in general and (b) specifically to the Antigua and Barbuda society. I use the following headings to guide my presentation: (i) impact on the Antigua and Barbuda Education system; (ii) affiliation with existing Literature and (iii) contribution to knowledge in the field.

9.6.1 Impact on the Education System

Over the years, in Antigua and Barbuda, with the Caribbean Examination Council's Board as mandatory examination body (1979 - present) informing certificates of graduates from the secondary education level, the process of education is employed in a mode not synonymous with economic activities in the global, regional and local markets. So although the prime goal of the education process in Antigua and Barbuda is that of preparing school leavers for the work place, this is secondary in the order of prioritization of operation in the CXC's agenda.

Preparation of students for academicism is the main focus of Mathematics teachers while using this examination oriented curriculum. Consequently examinations questions did not align with those focusing on preparation of students for the labour market. Hence I argue that there is a need for a complete refocusing of the Mathematics Curriculum to ensure the focus was indicative of preparation of students for the job market. Thus I hope policy makers will take on board suggestions from this research to begin the process of aligning classroom Mathematics Curriculum's content to one in keeping with national policies and goals.

Additionally, the Antigua and Barbuda Government should start to perceive the Caribbean Examination Council's Examination Board for what it is: a business enterprise, whose main goal was that of making a profit. The shelving of the Basic Proficiency's Mathematics Syllabus supports my claim. Hence the education process in Antigua and Barbuda should not be predicated upon the policies of the Caribbean's Examination Board's agenda. The nation's education process should be closely related to economic activities and skills required to produce labourers to handle the technological literacies that will characterise future workplaces in the labour markets, regionally and globally.

Nothing in the Caribbean Examination Council's revised (2010) syllabus has forecasted any unusual preparation for students to deal with the type of mathematics and skills, as mentioned in this research that will be needed in the labour market. Hence preparing students for future labour market roles using this Caribbean Examination Council's (2008) Curriculum could probably result in further marginalisation of Antigua and Barbuda school leavers in the job market. Hence, I hope that my research and the suggestions that I will be presenting to policy makers could produce the complete change needed in the mathematics education programme of Antigua and Barbuda.

9.7 Contribution to My Practice

Forty seven years of schooling to include sojourns at Institutions for Higher Education did not allow me to perceive myself as an educated person. This research has filled that gap. My research has given me new lenses through which to perceive and to understand the nature of the education programme that should be informing policies in Antigua and Barbuda. Elsewhere I have made the point that my net gain from having carried out this research is more, much more than I could have anticipated.

For the first time I am able to analyse the education process in Antigua and Barbuda and to provide suggestions to the question: what are we doing when we say we are educating our citizens? Today my suggestion is that instead of making our citizens masters of their own destiny and constructors of knowledge, the education model practiced in the schools of Antigua and Barbuda has rather made citizens consumers of knowledge.

My research has provided me with the understanding of what our educational goal should have been - one where the focus should have included making our students constructors or creators of knowledge. Not only have I acquired understanding, but I have acquired the means and methods which I could use to ensure that teachers, policy makers and practitioners could become researchers in their practices; equally as creating and generating information to inform teaching practice universally.

Hence from this exercise the components to become an instructor for the creation of knowledge, author and editor of academic papers and writer of educational books are now a part of my knowledge base. Equally, I am finally able to discuss educational matters in a scholarly manner and understand that all issues should be backed by research evidence and not opinions. Most importantly, the new effective and innovative strategies I left the context of my professional workplace to seek are now within my possession. Hence I should be able to better prepare mathematics teachers for their classroom duties.

However, I am aware that although claims are made by our political leaders and those citizens, including myself, specifically charged with manning the educational process and with appropriately preparing school leavers for the work place, so that our goal is one to provide the nation with a literate and efficient labour force, we have not lived up to this mandate. This is not a deliberate act on the part of educators but one borne out of the exogenesis encompassing the introduction of education into Antigua and Barbuda. Additionally our country's association in a regional grouping (OECS) has not always been beneficial for progress that was warranted to chart the way for education policies to inform a new technological era to cater to the needs of digital babies. The country's decisions for enacting of educational policies using the consensus trajectory, needs to be revisited; since the differences in economic activities and foci for economic growth among member states put Antigua and Barbuda at times in a disadvantageous position to advance the cause of nation building, while using this educational vehicle to appropriately prepare young people for the job market.

The Historical paradigm has been outlined in *Chapter 2*. The only conclusion that I can draw from that account is that historically the trajectory was one of academicism, and that the education programme was controlled by the syllabi governing examinations of those governing examination bodies. In Antigua and Barbuda the model is based on the Westminster model (17^{th} Century) brought to the colonies by Colonial masters. While Britain has moved on, to ensure that Educational practices are in keeping with the needs of the labour force, there has been no dismantling of the structures upon which the education system of Antigua and Barbuda was founded (see Education Act 2008, Antigua and Barbuda). Although there has been a change in the external board governing school leaving examination certificates, the trajectory is still one of a focus for academicism. My research has provided the evidence to support my claim of their having been no change in mathematics education programme in the last 50 years. Similarly the new Education Act of 2008 is still informed by parameters of the late 1950s.

The greatest contribution my research should make to the Antigua and Barbuda society is to emphasise the importance of research in every aspect and every spectrum of the education system divide. Education systems where research is a part of practice and where decisions are based on analysis and not opinions (example Britain, United States, Canada, Australia, Scotland, Finland, France, Switzerland, New Zealand, Germany, Finland, Netherlands, Brazil, India, Bangladesh, Singapore, Hong Kong, South Korea to name some known to me) have benefited from evidence based classroom practices.

My research has brought to the forefront the notion that in Antigua and Barbuda education is practiced as a system for acquisition of certificates rather than for the construction of knowledge. The construction of the knowledge process could only begin when lesson were taught with the aim of making our students creative, critical beings, searching for their own interpretations and suggestions to taught concepts. Hence not a certificate factory but rather a factory for construction of knowledge is the perception we should be inculcating in our students as the goal for their school's activities. This research has allowed me to start the thinking process for putting this suggestion into practice on my return to regular duties.

Regionally this research is significant since it could become the model for a change in educational practice in the Caribbean. Generally, Ministers of Education function as a unit, as seen from their membership to the OECS organisation. This research could be an agenda item for such a gathering, and the discussions emanating from the findings could begin the change needed in the Caribbean where the focus presently is on individuals who were more consumers of knowledge rather than innovative, constructors of knowledge possessing the skills necessary for the technological literacies informing the workplaces of the 21st Century.

One of my goals is the creation of a cadre of Mathematics teachers, well informed by research information. My research has brought to the forefront the importance of having trained and professional mathematics teachers informing classroom mathematics lessons. It has given me the opportunity to associate not only my work with those of experienced researchers in the field (Wake and Williams, Evans, Bakker, Engeström, Gates , Fisher, Ball, Thames, Swan and Noyes), but has also allowed me to position myself within the community of researchers, using the professional Mathematics teachers Organisations (IGPME, BCME, BSRLM soon to be ICIME), various research centres in my own University of Nottingham, example, UNESCO Centre for Comparative Education Research in my field of workplace mathematics, and in the socio mathematics paradigm.

Finally the fact that this research is the first of its kind in the Caribbean also makes it very significant. From my website search of documents in the workplace mathematics field, already information from this research is being used by the Ministry of Labour in Antigua and Barbuda. Additional information to inform the Labour Commissioner of the different mathematics requirements for the different workplace site is now at the Ministry's disposal – contained in a single document. Additionally this research is serving to highlight the areas in my own practice and the education system in general that are in need of changes.

With a claim by me for a curriculum more in keeping with the preparation of citizens for a 21st Century labour force, information from this research should be an asset to all constructors of this 21st Century Mathematics Curriculum; since mathematics required for different worksites and different departments within these worksites are listed in this research. My research has initiated the start for filling the gap and linking workplace knowledge to school classroom activities.

Hence in the future, there should be better preparation of students to master the technological literacies required for workplace sites and their chosen career trajectory.

9.8 Contribution to Knowledge

In Antigua and Barbuda where research is not a part of classroom practice; where there is no communication between classroom teachers and employers, knowledge of the mathematical needs of school leavers for the world of work is not readily available or discussed. However because there are several key areas of the labour force informing my research sites, I have been able to identify the mathematics needed at different work places for over forty five different careers in the job market in Antigua and Barbuda. Hence this is new information for the region. This should allow prospective employees to have a better understanding of the role of school based mathematics and its future role in their chosen careers.

My literature search in the field of workplace mathematics and my reading of several dissertations all indicate that this probably is the first dissertation with identification of the different branches of mathematics that was required for so many different sites in the job market and for so many different career trajectories in one doctoral thesis. Example, Naresh's (2008) workplace research has as its focus, bus conductors of India.

The general aim of this study 'was to gain an understanding of Chennai's Bus Conductor' mental mathematical practices at their workplaces and to examine what this knowledge could add to the study of every day mathematics (Naresh, 2008, cited in Wedege, 2011, p.6). Additionally Gahamanyi's (2010) '(Rwandan study)'s aim was to investigate how workplace mathematics can be contextualised and connected to university and school mathematics classroom practices so that mathematics becomes significant to the beneficiaries in both content and context' (Gahamanyi, 2010, p.18).

> *An additional study carried out in Iran by Azizi and Gavazi (2008, p.1) concentrated on t*he effectiveness of Secondary Education in Iran: the aim was to perform an external evaluation of the schools' connectivity to the workplace.

> Findings show that the country is struggling with a remarkable level of miss-matching between education and the world of work. Based on the opinions of school leavers and employers it has been also suggested that restructuring of secondary education was a strategic policy that needed to be considered seriously.

Identification of mathematics in the different sites is not highlighted. Hence my claim of my research providing the largest number of mathematics informing different careers and different sites in the workplaces, in the real world investigation in one document.

Further addition to knowledge occurred in the area where it is known that in general it is possible to identify two kinds of interest and perspective in educational research on workplace mathematics: (i) mathematics **for** the workplace (Gahamanyi, 2010; Aszizi and Gavazi, 2008) and (ii) mathematics **in** the workplace (Naresh, 2008). Researchers in the field choose for their research either (i) **for** the workplace *or* (ii) **in** the workplace.

This was an **and** in my research. Here my concern is vocational qualification in mathematics and how they can be developed through formal education: what kind of mathematics - in the form of mathematical ideas and techniques – is needed in the workplace? How can this mathematics – or mathematical skills – be taught and learned in school? (For example: Cobden et. al., 2010, Gahamanyi, 2010; Hoyles, Wolf, Molyneux–Hodgson and Kent, 2002); or within competence models (example, Hoyles et al. (2010); Magajna and Monaghan (2003); Smith and Douglas, (1997) cited in Wedege, 2011, pp.6 – 7).

These are the questions I asked at the beginning of this research exercise. These were the questions that brought me to this doctoral journey. Hence the competence model became my paradigm. Are we truly preparing students to handle the mathematics in work? What is the face of the mathematics in the work places of Antigua and Barbuda? It is the latter question that positioned me in the trajectory of research **in** the workplace. I realized that in order to provide suggestions to my questions in paradigm (i) a needs analysis was required to identify the mathematics in the workplace. Hence in my research the same parallel action was implemented as that implemented by members of the Advisory Committee on Mathematics Education, (ACME, 2011) in order to assess the mathematical needs of students for the workplace, here in the United Kingdom.

Hence my examination of the (ii) **for** paradigm. Here my main aim is to:

> *Understand workers' mathematical competences and practices within the complexity of workplace technology. What kind of mathematics is practiced? And how is it learned in work? The participants are experienced and competent – sometimes expert – workers. (Example FitzSimons et al. 2005; Hoyles, Noss and Pozzi, 2001; Kent, Noss, Guile, Hoyles, Noss and Pozzi, 2001; Kent, Noss, Guile, Hoyles and Bakker (2007); Wedege, (2002) cited in Zevenbergen, (2011, pp. 6–7)*

These are the hallmarks of my research (see Chapter 5 for description of workplaces' of participants informing my research). As I have mentioned, senior top level workers, experts in their field; managers of the business enterprises and resource training officers.

Unlike the 'performance model which focuses on the required qualifications in mathematics' (Wedege, 2011, p.5), the focus of 'the competence models is on the individuals' mathematical capacities in different contexts' (Wedege, 2011, p.5), in my research workers are exemplified by school leavers. I subscribe to the notion that my:

> *Study of mathematics '**in**' the workplace is related to my interest in mathematics education **for** the workplace, where mathematics education is to be understood in a wide sense including formal, non-formal and informal education, following the terminology of UNESCO (2000)(cited in Wedege, 2011, p.7).*

Hence unlike other research conducted in the doctoral exercise where it is generally research **for** the workplace or research **in** the work place my research merged the two perspectives: **' in' and 'for.'** I have not met this scenario in any other research in my literature search in this field. However, this is credible, for in accordance with views cited in Wedege (2011, p.9):

> *It is claimed that a study has to combine both general and subjective approaches in order to understand the cognitive, affective, and social conditions*

> *for adults' knowing and learning mathematics (see FitzSimons, 2002; Wedege, 1999, Wedege and Evans, 2006).*

Contrary to views expressed by Zevenbergen (2000): that 'researchers who seek to uncover the 'frozen mathematics' seek to legitimate the status of school' (cited in Wedege, 2011, p.8), that is not my intention in this research. Unmasking the frozen mathematics is my way of identifying the nature of the mathematics in workplaces and taking up challenges of Williams and Wake (2007) and Nicols (2002), that as an outsider I am able to identify the mathematics in work. Additionally, it is being investigated so that as a reflective practitioner I can ask myself what needs changing in my practice.

However, I support Zevenbergen (2000, p.186)'s claim that:

> *Research which seeks to understand the processes used in workplace contexts as being those of the participants and arising from the uniqueness of the context are more likely to challenge the status quo of school mathematics.*

Although this was never my intention, the findings from my research are causing me to challenge the status quo governing mathematics education in Antigua and Barbuda.

The challenges come in areas of (i) questioning the decision to have an examination based orientated curriculum informing classroom mathematics lessons when one of the goals of the education system is one of preparing students for the workplace; (ii) the weight given to the academic trajectory when this too is ultimately a trajectory focusing on preparation of students to enter the work force but at a higher rung on the pay roll of the workplace's ladder; (iii) the notion of having mathematics education for the state prescribed by testing agents whose predominant aim is that of making a profit and (iv) the practice of having summative assessment dictating teachers' classroom strategies whilst ignoring the practical and skill based components of the tool used to prepare students for workplace technological literacies.

Finally at the heart of my research are 'the key issues of the field: the so called transfer from school to workplace and vice versa and the invisibility of mathematics in workplace activities and competences' (Wedege, 2011, p.9). My research could pave the way for more Caribbean Educators to assume roles of practitioner-researchers and thus ensure that in the future educational practices are govern and founded upon 'evidence-based practice rather than practice-based evidence' (Gates.).

9.9 Summary

In this Chapter, I present further discussions to the findings. Coming out of the data is the fact that based on the increase in the use of technological tools in the workplace there is tension and a gap in knowledge between mathematics taught in the classroom and mathematics used in the workplace. Additionally, that the root of most of the mathematics problems facing students while learning mathematics in class rooms, could be attributed to the fact that most teachers teaching mathematics have no background in mathematical content knowledge, nor training in the art of teaching mathematics. Hence the system in Antigua and Barbuda as per se mathematics education is founded upon a cadre of teachers, teaching the subject but who are not mathematics teachers.

Hence this research should cause a change in the way that presently mathematical concepts are learned and taught. Also only trained teachers with a background, with a love and with a passion for the subject should be asked to teach the subject.

The findings are in keeping with those of other researchers in the field. The main theme permeating the discussion is the necessity for appropriate resources (qualified, professional mathematics teachers and 21st Century focused mathematics curriculum) to be used as tools in the school's mission to appropriately prepare school leavers for the workplace.

Chapter 10 - The Way Forward

10.1 Overview

In this chapter I use the following subheadings: (i) introduction; (ii) recommendation; (iii) implications; (iv) limitations; (v) reflection; (vi) concluding reflection and (vii) areas for research.

10.2 Introduction

Four years subsequent to my leaving the context of my practice, the mission that brought me to the portals of the University of Nottingham, specifically its School of Education's Research Department, has ended. Although the suggestions obtained in this research were obtained from the use of a specific frame work – the Engeström's (2001) Second generation model activity theory; that findings from the research could have been different from having used alternative frameworks; the outcome using the present framework has indicated that there were possibly favourable results that could be gained, by making the findings from this research, part of my practice.

The findings from the research have since suggested that the Mathematics Curriculum used in the Secondary Schools in Antigua and Barbuda *was not* appropriately preparing school leavers for the workplace. The main reason advanced to support the claim was that the tools employed to perform the mission were inappropriate for the job. Secondly because the main focus of teachers was that of preparing students to pass an examination, no appropriate preparation of students for the workplace could have been achieved during classroom mathematics sessions. And although the newly employed were able to handle the mathematics in work, on–the-job training was chiefly responsible for this feat. Thus with the increase in technological tools in the workplace and because the format of workplace mathematics was different from classroom mathematics there was tension in teaching of classroom mathematics to prepare students to handle the mathematics at work. In fact teachers showed no knowledge of making the connection with classroom mathematics and workplace mathematics. In their view, classroom mathematics was solely for academic trajectory leading to matriculation for tertiary education.

10.3 Recommendation

I draw on the work of Dillon and Maguire (2008) in my claim 'that how well we cope in life, either as individuals or as nations, depends essentially on our knowledge, skills, creativity and attitudes (Brown 2008, p. xvii). It is further my argument that 'Teachers are critical in helping us to develop each of these qualities. So ultimately, our future *depends on the expertise and commitment of teachers'* (Brown, 2008, p. xvii).

This clearly puts a premium on producing the best possible teachers, through the highest quality of education and training (Brown, 2008, p. xvii). Undoubtedly I would argue that there was the need for preparation of teachers, not only to fit well into the way schools currently operate, but also to have the ability to adjust to future change. Despite the limitations of current practices, teaching is a skilled profession. It requires not just the expertise to respond to routine classroom situations, but a deployment of a wide variety of skills in order to deal with any specific problems that may arise (Brown, 2008). For example, teachers should be able to provide suggestions to the following questions:

> *What is the best way of presenting this material so that it will engage this class?*
>
> *Why does this student find it difficult to learn this? And*
>
> *What can I do about it?*
>
> *What would be a fair and appropriate way to assess understanding of these ideas?*
>
> *(Dillon and Maguire, 2008, p.xviii)*

I would argue that 'to be able to solve such problems, teachers need to develop their knowledge on several fronts*:*

First of their subject areas

Second of how students learn or fail to learn; and why they develop specific attitudes and behaviours and

Third of the most effective ways of teaching, both at the general level and at the level of the specific concept or skill, including available teaching resources

(Dillon and Maguire, 2008, p.xviii)

Indeed:

Teachers need to be able to deal not only with issues that arise in their classrooms, but also that confront schools as a whole (Dillon and Maguire, 2008, p.xviii).

Therefore:

Decisions need to be made on what curriculum to offer, what methods of assessment and recording of progress to use, how to group pupils, how best to deploy resources of people and money, and a wide range of other such issues (Dillon and Maguire, 2008, p.xviii).

In Antigua and Barbuda research should become part of all future educational policies and practices. In countries where research was part of practice and policies, 'more and more research is becoming available to inform the decisions that teachers make both individually and collaboratively' (Dillon and Maguire, 2008, p.xviii).

It is a well held belief that the United Kingdom's Education system, was one of if not the best in the world. When one looks at the role of research activities it would be difficult not to attribute some of this success to its research facilities. In a paper prepared for a presentation for the Commonwealth Education seminar the impact of research activities were reported as depicted in Figure 9.3.

Although some research studies are small in scope, when taken together with other national and international research, reliable evidence could often be accumulated to indicate which strategies are likely to be most effective in which circumstances (Dillon and Maguire, 2008, pxviii).

For the 21st Century and beyond I would argue that there is the need for a change in our educational practices; where there was a change in decision making founded upon ‘practice based knowledge to the alternative change led by evidence based practice. Where research was involved the analysis needed to be carried out systematically. Since there has to be analysis and not opinions informing’ (Gates). Additionally there was ‘the need for precision in language and precision in explanation (Fisher) of all educational matters.

I am suggesting that ‘all teachers should be acquainted with the most recent research findings, since our students in schools were entitled to the best informed teachers and teaching we could provide’ (Dillon and Maguire 2008, pp. xix – xx).

It is my hope that this thesis will interest, will stimulate, and will be instrumental in serving the aim I am striving to achieve: improving the quality of teaching and learning of mathematics in schools in Antigua and Barbuda. Arguably, it is within this paradigm that appropriate preparation of students for the work place could have its origin in the future. As suggested from conversations with policy makers and with head of schools, these were the pertinent areas for changes as outlined in the figures from each of the demarcated activity systems using the contradiction discursive table’s tool.

10.4 Implications

This research has given me a wider perspective from which to view, interpret and examine practices, issues and policies associated with the management of the education system in my country. It has also served to bring to the forefront the power of research whilst searching for suggestions to improve one’s practice. Lessons learned by me would include: understanding the genres underpinning how children learned; the function of assessment in driving the education practice in any country; the need for understanding the goals and the missions of one’s education system; importance of having trained teachers whose subject discipline is from a mathematical background informing classroom lessons; the need for there to be a link between the school and the workplace; by extension between teachers and employers. Arising from this there should be opportunities for students to visit workplaces and for seminars or lectures from professionals in students' chosen career trajectory to be part of the mathematics programme.

There would, therefore, be the necessity for a support system for teachers and a support system for students to be integrated into mathematics classroom practice. Teachers should also be encouraged to ensure that research was part of classroom practice. In fact, as the change agent, this would be one of the innovations I would be suggesting for the mathematics programme. This research has allowed for my understanding the effect of rote learning on students' intellectual development; on the inability of "A-*students"* to perform at the expected standard in a workplace environment, the place of school mathematics in preparing students for the workplace, was also newly acquired knowledge on my behalf emerging from the analysis of this research. These all served to point in the direction for initiating and organising of several mathematics organisations and a research centre. Mathematics Education seminars to the public will also be a new innovation.

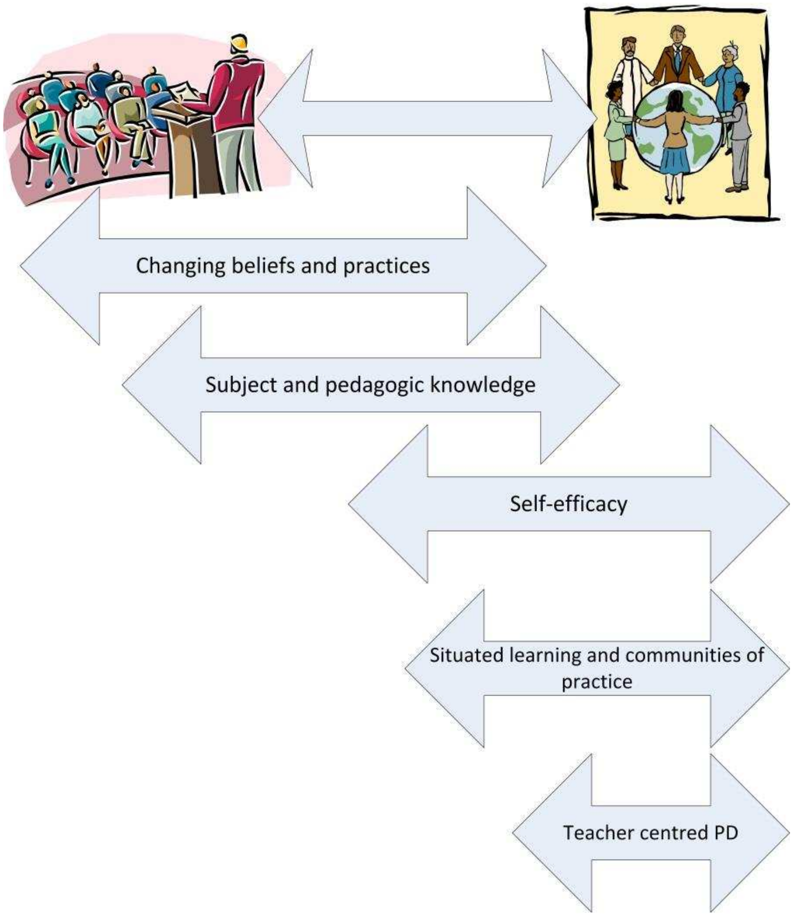
Being given the opportunity to gain membership in several distinguished World, International organisations (ICME, IGPME, BSRLM, BCME) has also allowed me to benefit from current research findings in the mathematics field. Additionally meeting with renowned researchers in the field of education and keeping in contact was another means of ensuring that research literature would inform my practice in the future. It is one way of ensuring that my practices in the future would be evidence based; there would be analysis and not opinions employed in resolving issues arising in my practice. Teachers by their willingness to join such professional organisations could improve their mathematical knowledge. This could only enhance the quality of the mathematics teachers. The professional genres needed to change the teaching and learning of mathematics in Antigua and Barbuda's Schools could be the alternative benefit.

The findings from this research have suggested that there was a need for quality teachers - teachers trained in the art of teaching mathematics, to teach the lessons to students. It also served to highlight the fact that the boundary of teachers' mathematical lessons could not remain within the parameters of their mathematics knowledge learned during their schooldays. Rather, teaching strategies and knowledge to improve and compliment teachers' classroom practices and professionalism should be founded upon mathematics literature provided by current research in the field. Labourers for a 21st Century labour force required tools commiserate with the Technological Literacie*s* needs of the highly skilled jobs informing operations in the workplace.

Additionally this research has suggested that there was an urgent need for the practical component to be introduced as part of the classroom mathematics syllabus. Since the school was the institution mandated to provide the Antigua and Barbuda Society with the appropriate workers for the job market, mathematical skills required at the workplace should be taught in school. This was necessary since the World Bank's Researchers (2007) have forecasted a discontinuation in practice of the on-the-job training for prospective low skilled workers. Consequently there was the need to change how mathematics was being taught and being learned in schools. In order to achieve this goal, teachers should secondly be made aware of the goal, aims, and objectives of the mathematics lessons they were hired to teach students. The content of the mathematics syllabus and the associated tools should ensure that the trained mathematics teachers' role could be achieved. Therefore, resources should also be appropriate for the task. At the moment teachers' fears are of the same nature as those expressed by teachers from the East Midland's here in Nottingham in Swan's and Noyes' (2010), East midland project. These are:

Figure 10: Factors that could improve mathematics education

Source: Swan, M. and Noyes, A. 2010.



- Teachers perceive conflicting demands between getting students through test and developing teaching and learning
- Teachers find it very difficult to change their practices

Therefore I will be challenged to help teachers come to terms with their fears. I shall be relying on the educational theories of learning to help in this process. These theories could include:

Ideological spectrum of teacher learning theories

- Theoretical perspectives on teacher learning
- Teachers' beliefs and practices (Fenstermacher, 1978).
- Teacher Knowledge – subject and pedagogic (Shulman, 1986).
- Changing practices to change beliefs (Guskey, 1986).
- Situated learning and communities of practice (Lave and Wenger, 1991)
- Teacher centred PD (Huberman et al., 1993)
- Self-efficacy (Bandura, 1977)

Similarly policy should be parallel to the school's mission. Therefore an examination oriented mathematics syllabus should not be the tool employed to use in preparation of students for a labour force. Additionally teachers should not be asked to address two objectives using the content of a single mathematics syllabus. At the moment in Antigua and Barbuda there is a contradiction in policy. Here teachers are being asked to use an examination oriented syllabus to prepare students for the workplace. However, the content that would allow for appropriate preparation of students for the workplace is missing. This is not in convention with effective or productive education policies (See Japan's, Singapore's, Finland's, New Zealand's, Australian's and the United Kingdom's Educational system). Classroom mathematics lessons need to change from a teacher led focus to a child centred focus. Here the teacher's role would be that of a facilitator.

10.5 Limitations

As a research executed in the interpretive qualitative paradigm, all known limitations of research conducted in this trajectory would have been affiliated with my research. However, as it relates specifically to my research, I argue that in a research exercise with one researcher interpreting the data, there would always be limitations to the overall findings. For the lenses through which I view the world and my interpretation of various phenomena and occurrences in nature, based on my epistemological position as a relativist, will be different from that of others, sharing the same space on this earth, at any given moment. In this research the experience would have been the same. Some of the limitations to this study could therefore be classified thus: the boundary of the study was small. In light of this the information forming the focus of the report was only from a small geographical area with uniformity in environmental conditions. This included topography, climatic conditions and socioeconomic background of the participants.

Additionally the participants and the research sites were from a purposeful sample. Hence no generalization was possible. Size also played a factor in the present study in the area of the anonymity law. Despite the deployment of ethical rules, the small community could allow for the identification of the individual(s) offering suggestions for certain issues. In Antigua and Barbuda there is only one Director of Education and one officer in charge of each of the time tabled subject disciplines. Hence this could have provided a disadvantage and therefore a limitation to the data collected. Simultaneously there was always the underlying concern of officers released from official daily practices, engaging in any research exercise to return to duty; in preference to spending would be extended periods trying to ensure that the suggestions from the data were all exhausted.

This research has also demonstrated the need for funding. This could have allowed for a sharing of the work load. Hiring of some assistant researchers could have made a difference to the diversity in the offered suggestions. Thus information coming from several different researchers' perspectives could have further enhanced the richness of the qualitative research. Simultaneously because of the short period in which the research was undertaken it is beyond the aim of this research to examine findings in any great depth for a long period. Word constraint on the written report of the findings was another limitation. Some of the data had to be canned because of this word limit.

Yet, despite all these limitations, because my research was helping to identify the gap between 'realistic goal of the vision of policy and the actual classroom implementation of the policy' (PME33, 2009, p.2-103), I am hoping that the net result will be advantageous to future educational policies and educational practices in the twin island state of Antigua and Barbuda and neighbours of the Diaspora, in the grouping to which we belong (OECS).

10.6 Reflection

In this section I draw on the work of Wesch (2008), since I support the view that the '21st Century will require knowledge generation, not just information' (p.2). Additionally, questions to include the following could become custodians of our thoughts: 'how mathematics education could be structured to meet the needs of students in the 21st Century? Also, how do we now define '"school", "teacher", "learner" and "curriculum"' (Wesch, 2008, p.2)? It is my argument that since:

> *Delivery and schools will need to create a "culture of Inquiry", 'Schools in the 21st Century will be laced with a project –based Curriculum for life aimed at engaging students in addressing real-world problems, issues important to humanity and questions that matter (Wesch, 2008, p.2).*

Consequently this will represent 'a dramatic departure from the factory model education of the past. It is abandonment, finally of text-book driven, teacher-centred paper and pencil schooling. It means a new way of understanding the concept of "knowledge", a new definition of the "educated person" (Wesch, 2008, p.2). It was for this reason that I was suggesting that there would be the need for 'a new way of designing and delivering curriculum' (Wesch, 2008, p.2) no one could dispute that there would be the need for a change in definition of the following terms to now state:

> *Schools: 'nerve centres with walls that are porous and transparent, connecting teachers, students and the community to the wealth of knowledge that exists in the world' (Wesch, 2008, p.2).*

> *Teacher: 'Orchestrator of learning and helping students to turn information into knowledge and knowledge into wisdom' (Wesch, 2008, p.2).*

Learner: in the past a learner was a young person who went to school, spent a specified amount of time in certain courses; received passing grades and graduated. Today, we must see learners in a new context:

First – we must maintain student interest by helping them see how what they are learning prepares them for life in the real world.

Second – we must in still curiosity, which is fundamental to lifelong learning.

Third – we must be flexible in how we teach.

Fourth – we must excite learners to become even more resourceful so that that they will continue to learn outside the formal school day (Wesch, 2008, p.3).

Therefore, when the following questions become the foci of my conversations:

What will schools look like, exactly? What will the curriculum look like? How will the 21st century curriculum be organized? And how will it impact the way we design and build schools? How [do] we assess students? How [do] we purchase resources? How [do] we acquire and utilize new technologies? And what does all this mean for us in an era of standardized testing and accountability (Wesch, 2008, p.3)?

I would draw on the work of Wake (2011, p.1) and declare, I like many other researchers in the field of workplace mathematics will be adopting a socio-cultural theoretical perspective. Ideas of expansive learning and developmental transfer appear to offer potential for vocational and possibly well-focused pre-vocational education.

In addition to already suggested curriculum formulation cited in Chapter 9, I would further propose that:

In the future, general mathematics curricula should introduce new practices for students that prioritise making sense of, and developing further, the mathematical models of others. This provides a major challenge in strategic curriculum design and I draw attention to three major factors that such design needs to take into account:

(i) ***Specification*** *Mathematics curricula are often specified by stating mathematical content that should be learned. In developing a curriculum as suggested here it is important to emphasize expected outcomes in terms of new skills and competencies that learners require in understanding, and being able to develop, mathematical models. There is currently limited understanding of how learners might best de-couple mathematics and reality in ways that allow them insight into each. This an under-researched area, but one that might be informed by the substantial body of research into use of mathematics in workplaces.*

(ii) ***Support*** *Because of the novel nature of the proposed curriculum there is a need to identify a range of rich resources to support the required activity: again there is perhaps the potential to draw on workplace research case studies to develop some of these.*

(iii) Pedagogy *It is important that teachers do not consider how they might reduce the expected enquiry activity to a set of new heuristics. It is likely that they may need to re-conceptualize their role to become a supporter of joint enquiry rather than transmitter of mathematical expertise. This suggests a major shift in the typical didactic contract with mathematics learning being considered a workshop-situated and inquiry-based activity.*

> *The approach proposed here tackles issues of transfer directly by placing the study of how mathematics models reality at the core of the curriculum. Uncoupling mathematical concepts from the situation they model and making sense of each and their interrelatedness becomes central to the mathematical activity of the student. Consequently students will be expected to explore how mathematics can be transformed to meet the needs of a range of diverse situations, with at times a focus on the coupling, and at other times a focus on the development of the mathematics itself. This suggests the need for continued research and development in this area of major importance to future worker expertise and adaptability (Wake, 2011, p.7).*

The principle upon which Wake (2011) established his proposal for the Mathematics Curriculum befitting class room mathematics for the 21^{st} Century will act as template for a similar curriculum which I will be suggesting to suit the Antigua and Barbuda context. However, drawing, on the work of McLeod (2008, p.1) captioned *'Education in the 21^{st} Century',* I argue that there is need to 'adopt a new paradigm of mathematics education for the 21^{st} century. This is necessary since most people today adhere to a paradigm of mathematics education that was strictly 19^{th} Century and thus irrelevant to the mathematics required in the job market'. I support the growing number of educators who believe in and accomplish the impossible.

Hence, in my role as the Mathematics Officer, responsible for the Antigua and Barbuda mathematics classroom programme, I accepted full responsibility of leading the way in taking the nation into the 21st Century mathematics paradigm. It is not enough to say that we are living there. Whereas I know that technically it is the 21st Century, I am aware that our schools are not there. Therefore, the challenge for me is to invent a mathematics programme for the 21st century in order to ensure that our children, our students could be appropriately prepared for living in this century (McLeod, 2008).

Thus in the future when I think of education, I do not want to be thinking of the way I knew school. I want to think about it as that befitting the characterization of 21st Century education: '21st Century education is bold; it breaks the mould; it is changing world fill with fantastic new problems as well as exciting new possibilities' (McLeod, 2008, p.1). There is a growing body of research supporting an increasing number of 21st Century Schools. It is my plan to ensure that schools in Antigua and Barbuda will soon be caretakers for one of those numbers. The new millennium was ushered in by a dramatic technological revolution. The students we are preparing for living in this era, now live in an increasingly diverse globalize and complex, media saturated society.

Although none of us could know what the world would look like when today's kindergarteners will be retiring from the job market, our duty today is to prepare them to take up meaningful roles in the job market. The issues faced by these students (Global warming, famine, poverty, health issues, a global population explosion and other environmental issues) there is the need for students to be bold to communicate, function, and create personally, socially, economically and politically on the local, the national, and the global levels. At the same time skills to accommodate exigencies of the Technological Literacies in the job market should be part of their knowledge base from the preparation exercise in classrooms for the job market.

Therefore 21st Century Schools should recognize the critical need for developing 21st Century skills. Thus the education paradigm should embrace the components of authentic education. This education addresses '*the* "whole child", the "whole person" and does not limit our professional development and curriculum design to workplace readiness. Therefore 21st Century skills should be learned with a project based curriculum by utilizing the seven survival skills proposed by Wagner (2008) in his book, *The Global Achievement* gap:

- Critical thinking and problem solving
- Collaboration across Networks and leading by influence
- Agility and Adaptability
- Initiative and entrepreneurialism
- Effective, Oral, and Written Communication
- Accessing and analysing information
- Curiosity and Imagination

10.7 Concluding Reflections

Drawing on the work of Wesch (2008), I ask you to travel with me into the future where I will be putting into practice all that was suggested during this research. I will be employing *Principle 5 of the foundation* for the Engeström (2001) Cultural Historic Activity Theory (CHAT), upon which my Theoretical frame work was founded in order to initiate the proceedings (see Chapter 4).

I am excited about the prospects of a positive outcome and the benefits which will accrue to the entire education system of Antigua and Barbuda. In fact in my dreams I have already seen:

> *A school in which the Students- all of them – are so excited about school that they can hardly wait to get there (Wesch, 2008, p.3). Additionally, it is a school with 'little or no "discipline problems" because the students are so engaged in their studies that those problems disappear. I 'imagine having parents calling, sending notes, or coming up to the school to tell me about the dramatic changes they are witnessing in their children: newly found enthusiasm and excitement for school, a desire to work on projects, research and write after school and on weekends . Furthermore, I imagine my students and Teachers making nearly 'exponential growth in their basic skills of reading, writing, speaking, listening, researching, scientific explorations, math compete skills and or more (Wesch, 2008, p.3).*

This is my dream for the new culture informing mathematics Education in Antigua and Barbuda. I am confident that this research will allow for the acquisition of methods and strategies which could be instrumental in the realisation of my dream of changing the teaching and the learning of mathematics in classrooms of Antigua and Barbuda. Also of ensuring that practices will be evidence based and decisions will be using literature from research in the field.

Finally research will be a part of classroom practice; the necessary teachers' and students' support will be headed and guided by me. Nothing will be left to chance. I know that I have all these techniques and knowledge within my professional repertoire to cause a revolution in the teaching and the learning of mathematics. I have the determination and the indomitable will to ensure that all these procrastinations should come to pass.

It is possible. It has happened and is happening, in schools in other countries (United States, Hong Kong, United Kingdom, Finland and India). There is growing evidence of schools everywhere having the same results when they implement a 21st Century curriculum. It is now the time for this action from the Antigua and Barbuda Education Policy Makers.

10.8 What Should be the Way Forward?

Because of our government's structure, education policy is controlled by the politicians. Therefore we need to make policy makers aware of the problem. Also, since mathematics is a specialized area, constant upgrading of content to ensure the relevance to present situation is achieved, should be on going. Simultaneously, expert in the field should be retained for consultancy purposes to ensure first class information is disseminated among curriculum developers. In Antigua and Barbuda educators should seek to sensitize the public as to the key role mathematics will be performing in our new economic trajectory of the *Service industry*. Indeed mathematics will be the basis for this new economic industry.

Unfortunately all these decisions will have to be made against a background that as part of a regional organisation (OECS) we are not free to put into action our own plans. This is one of the limitations that we have to absorb; since all educational policies made in Antigua and Barbuda have to go to OECS Minister of Education meetings for ratification and acceptance. The problem is, because of different stages of development and economic trajectories among member states, consensus is not always readily available. However with most members now buying in to the concept of building their economies on the service and financial trajectory, now, more than ever, there is the need to train teachers to meet the new dimensions that will be required in mathematics education. There will be the need for retraining of policy makers since the focus now is on application, critical thinking and reasoning as opposed to memorisation and rote learning. Thus the need now is for the Government to reinvest in mathematics education beginning from primary to secondary school, ensuring that information focusing on new technological devices is incorporated into the content of the mathematics curriculum. This would ensure appropriate preparation of students for future workplaces where technological tools are increasingly part of daily routine. This is also going to require better management of resources to ensure efficiency and effectiveness in teaching a vast cross section of students. Distant teaching and using of the technological devices from a central point should become part of the new teaching strategy. Dull, boring, chalk-and-talk and lecture format should be used minimally. Twenty first century teaching strategies and pedagogy needs to be the focus of the mathematics classrooms from now going forward.

10.9 Areas for Research

Although at the moment the focus will be on implementation of suggestions from this research, since professional development of teachers will be one of my main areas of concern, research will be executed in this area. Benefits of teachers' professional developments, the impact of their knowledge and their training have not been highlighted or demonstrated in their teaching of mathematics to students in their classroom. In fact no research has taken place to examine the reason for students' lack of comprehension for taught mathematics concepts (Kennedy, 1999). This has resulted in teachers using the same pedagogic strategies and methods to teach mathematics in secondary class rooms for the past 50 years. Hence this is one of the suggested areas for research. Additionally, research could be executed at other job sites which were not a part of my research in order to examine the mathematical needs at these worksites. Building on findings from this research and proposition for a new format to curriculum design for the 21st Century, additionally there could be research to examine the most appropriate format for the content of the proposed 21st Century Mathematics Curriculum to address classroom lessons.

Specifically as it relates to the job market 'The OECS Ministers (to include Antigua and Barbuda) and the OECS Education Reform Unit (OERU) are involved in on-going curriculum reform, but no formal studies have been carried out to determine labour market needs' (World Bank Researchers, 2007, p.14). Hence this could provide still another area for research. Presently a 'thorough assessment of the relevance of the CXC exams, syllabi and indirect curriculum for the labour market is not available' (World Bank Researchers, 2007, p.15).

While the findings of this research were affiliated specifically to the Mathematics Education Programme in Antigua and Barbuda, many of the recommendations may be relevant to other countries' educational contexts and to professional development in general. Thus I would argue that my research could serve to add to our understanding of mathematics teachers' beliefs and practices in the area of academic mathematics instruction. Indeed my research could initiate the attention needed to be paid to the role of *Reflection* in teachers' practice. Hence it could be the catalyst to enable teachers to reflect on and to examine their own beliefs and their teaching of mathematics in formal settings.

Hence this study calls for more research on Antigua and Barbuda Mathematics Teachers' beliefs and practices in the area of mathematics instruction. This could allow for advancement in our knowledge of how mathematics teachers think and act. It could also allow us to arrive at appropriate suggestions to bridge the present gap between research and practice. More suggestions would be taken on board as teachers were made aware of the important role of research literature to their practice. For as noted by the Caribbean Examination Council (2011) in the article captioned *Rethinking Education in the Caribbean* (2011, p.8):

> *Research and access to information is now instantaneous and the technologies have facilitated the hybridization of knowledge to an unprecedented extent. As a result it has been estimated that by 2020 the knowledge base could be changing every two hours! Whatever the exact pace of change, it is sufficiently rapid to mean that traditional syllabi and curricula will no longer serve as adequate registers of received knowledge.*
>
> *A major implication of this paradigm shift is that the age old question of what is to be taught will shift to what are the competencies that are required to certify mastery in any particular knowledge domain. Content will give way to competence; analytical skills will supersede memorization.*

This research has highlighted the fact that in general the mathematics education programme in Antigua and Barbuda (along with the rest of the Caribbean) was no longer working. This was supported by a research, sponsored by the Caribbean Development Bank, and executed by George (2011) and published in a document entitled: *The OECS Education system at Risk.* The Caribbean Examination Council's view was that this was due to the fact that: 'we have not approached reform in a truly systemic manner' (2011, p.8).

I would also add that this was due to the fact that research was not a part of educational practices. Therefore, the knock-on effect of problems in one sub sector creates other problems in another. As was implicit in this research, the deficits in primary education translate into weak performance at secondary (Caribbean Examination Council, 2011). As a product of the aforementioned malaises, in Antigua and Barbuda the Secondary Mathematics Curriculum was **not** appropriately preparing school leavers for the job market**.** More significantly, with the increase in technological tools in the labour market, there are tensions and a gap between mathematics taught in school and mathematics for the labour market.

10.10 Summary

This research was carried out to secure strategies to create new methods for teaching and for learning of mathematics in the classrooms of Antigua and Barbuda. Additionally, the research examined the claims of employers that school leavers were not appropriately prepared for mathematics in the workplaces. However, the main research question whether or not there are tensions and a gap between mathematics taught in classroom and those required for the workplace resulted in the discovery of pertinent suggestions that will help to revolutionize the mathematics education programme in the Secondary Schools of Antigua and Barbuda.

Findings from the research suggest that school leavers were able to handle the mathematics in the jobs at the workplaces because of on-the-job-training offered to new employees. Additionally, in the workplace, mathematics was wrapped up in the work that employees were called upon to perform on a daily basis. Therefore, for most employees these activities soon became operations. The teamwork and cooperation among employees at the worksites also ensured that the employees were able to accomplish workplace mathematical activities. There was no correlation between teachings of mathematics in the workplace with school's pedagogies. There were marked differences in how instructions were transmitted to individuals.

Where technological gadgets were a part of work, competency in handling of the technological device was the knowledge that employees had to learn. The mathematics was wrapped up in the operation of the tools and the employees were only called upon to use results (pushing or pulling a button; or turning of a knob to acquire the desired results). Hence this was an achievable mission for school leavers. Nevertheless newly employed were also called upon to learn the behind the screen operations to the mathematics used at work.

However, as indicated in the literature, the curriculum cannot teach on its own. Therefore, it was with the human factor that the responsibility for appropriate preparation of school leavers for the workplace resided. In the Antigua and Barbuda Mathematics Classroom there could be no appropriate preparation of students for the workplace, since the main focus of teachers was that of preparing students to pass an examination. Additionally most teachers teaching mathematics in the secondary classroom were untrained in the art of teaching mathematics and were only in possession of secondary school mathematics subject knowledge. This was inadequate for teaching of mathematics to students.

Furthermore, the curriculum used by teachers to teach secondary mathematics has as its main focus an examination orientation. As claimed by Havnes (2007) a curriculum cannot be used to carry out two distinct and separate objectives.

Hence these were the perspectives from which students were inappropriately prepared for workplace activities using this Secondary Mathematics Curriculum.

Thus in concluding I would claim that the Mathematics Curriculum used in the Secondary Schools of Antigua and Barbuda was expected to perform a mission for which it was not constructed.

Similarly, teachers were being asked to prepare students for workplace mathematical activities using a tool that was inappropriate for the mission. Simultaneously, most teachers teaching mathematics were not trained in the art of teaching mathematics and had no background or subject knowledge in mathematics. These were the main factors impacting negatively upon classroom mathematics lessons, but which did not affect students' ability to handle the mathematics which was a part of their daily routine in the workplace. On-the-job training compensated for inappropriate class room deficiencies. The work now for mathematics teachers is to bridge the existing gap between classroom mathematics and mathematics in the workplace by ensuring appropriate preparation of students for the highly technologically skilled requirement for future employees.

APPENDICES

Appendix A Code of Ethics approval forms

Please outline any areas of risk, which have not been referred to above, associated with your research, and how you intend to deal with these (continue on a separate sheet if necessary):

Checklist:

Please check that you have attached the following and return with the form to the Postgraduate Research Students Office

(1) a brief statement of my research aims or questions and proposed methods of data generation (maximum 200 words); ☑

(2) a brief statement of how I plan to gain access to prospective research participants; ☑

(3) a draft information sheet to be provided to prospective participants; ☑

(4) a draft consent form to be used with prospective participants. ☑

NB Please do NOT include copies of research instruments (e.g. questionnaires).

Signed (student) Caron O. Weston Print Name (Student) CARON O. WESTON Date 26/02/09

Signed (supervisor 1) ______ Print Name (supervisor 1) Carol OATES Date 18/3/9

Signed (supervisor 2, where appropriate) ______ Print Name (supervisor 2, where appropriate) ______ Date ______

PLEASE RETURN THIS FORM WITH SUPPORTING DOCUMENTATION TO THE POSTGRADUATE RESEARCH DEGREES OFFICE (A77)

Appendix B - Letter to Participants Inviting Them to be a Part of My Research

Instruments for Field work

General Salutations

Hello, my name is Caron Weston, Education officer of mathematics from the Ministry of Education. At the moment I am on study leave and now a Doctoral Research Student with the University of Nottingham, attached to the school of Education. Presently, I am conducting the fieldwork to my research topic captioned*: Is the mathematics curriculum used in the secondary schools of Antigua and Barbuda adequately preparing school leavers for the job market*? This research is being undertaken to advance and improve the teaching and learning of mathematics in our schools in Antigua and Barbuda and ultimately to improve the economy and life of the residents.

It is my belief that the time has come, when students in Antigua and Barbuda must take their rightful positions in the international knowledge Economy. It is the education system which must be the main tool in helping us as a nation to realize this goal. Our first requirement is the provision of a literate labour force. This will ensure the capacity of workers to face the challenges of the jobs at the various workplaces. It is thus, for this reason that today, I am asking for your support in helping me to understand the nature of the jobs at the various workplaces, where school leavers will seek employment. At the same time I must assure you that your job is also important in this data collection exercise. Therefore, it would be appreciated if you would allow me to engage you in this small conversation for the next thirty minutes as I try to gain an insight into the nature of your work.

Thank you for agreeing to be a part of this data collection exercise. The nation of Antigua and Barbuda will be the benefactress from this exercise. As the saying goes: "Your country needs you now" (BBC TV Show: Theme for Europe Contest, 2009).

Caron O. Weston

Doctoral Research Student

Centre for Research on Equity and Diversity in Education

UNESCO Centre for Research and Comparative Education

School of Education

Dearing Building, Jubilee campus

University of Nottingham

Wollaton Road

Nottingham

NG8 1BB

Appendix C - Consent Form for Participants

From: Caron Olivene Weston

Direct line: 4633504
Email: ttxcow1@nottingham.ac.uk
http://www.nottingham.ac.uk/education/
Mobile: 7744740

The University of Nottingham

School of Education
Jubilee campus
Nottingham NG8 1BB
Wollaton Road

Is the mathematics curriculum used in the secondary schools of Antigua and Barbuda preparing school leavers for the work place?

This Research project is being undertaken to advance and improve the teaching and learning of mathematics in our schools of Antigua and Barbuda and ultimately improve the economy and life of our residents.

Data will be mainly based on interviews with various people involved in the design and delivery of the mathematics curriculum. Interviews will be conducted to find the philosophy underpinning delivery of Education in Antigua and Barbuda; what mechanisms are in place to facilitate this; what are some of the issues confronting employers as they relate to the newly employed; and how do students in our schools know that the curriculum is preparing them for the workplace.

It is thus for this reason that today that I am asking for your support, by allowing me to engage you in this thirty minutes conversation. During this process I will not only be seeking to gain an insight into the nature of your work but also to collect data that will assist with the provision of answers for the research question. Thank you for agreeing to be a part of this data collection exercise.

- I have read the above information on the research project. I understand the purpose of the research project and my involvement in it and agree to take part.
- I understand that I may withdraw from the Research at any stage.
- I understand that while information gained during the study may be published, I will not be identified and my personal information will remain confidential.
- I understand that I will be recorded during the interview. *{Delete if the interview will not be taped}*
- I understand that data will be securely stored but at the University on one computer and will only be accessible by you (The researcher) for the purposes of this Research.
- I understand that I may contact the researcher if I require further information about the research exercise, and that I may contact the Research Ethics Coordinator of the School of Education, University of Nottingham, if I wish to make a complaint relating to my involvement in the research. (Tel: 01144 11595144867, or email to john.holford@nottingham.ac.uk, or write to the above address)

Signed ....(Research participant)

Print name .... **Date** ....

One copy should be given to the participant and one copy should be retained by the researcher

Appendix D - Research Tool for Interviews with Six Heads of Mathematics Department of Secondary Schools

(i) What is your function as the head of the mathematics Department?

(ii) What has been your greatest challenge in this role?

(iii) What is the major challenge Students encounter while learning mathematics in the classroom?

(iv) What would you consider as factors responsible for the things you have highlighted?

(v) Is there any relationship between the content of the mathematics curriculum and the students' way of life?

(vi) Is there any relationship between the content of the mathematics curriculum and the students' way of life?

(vii) Does the content of the curriculum address the different trajectories of students?

(viii) Would you say that school leavers are in a position to handle the mathematics that forms part of daily routines at their workplaces?

(ix) Is there a need for teachers to change their methods/ strategies used to teach mathematics lessons

(x) 10) The last word is yours

Appendix E - Interview Questions for Principals of Secondary Schools

What has been the general operations governing the teaching and learning of mathematics in your school?

Are there known factors that have contributed to the status you have just outlined to me? (in the case of Sir, responsible for the method of allocation of teachers at the various year groups)?

How has this action impacted mathematics education in your school?

How relevant is the mathematics learnt in the classroom as per se students' career path?

Has there been any noticeable change over the years in students' attitude towards the subject of mathematics?

What do you perceive as seemingly the main focus of teachers who teach mathematics?

Is there a need to change any aspect of how mathematics is learnt and taught in your school? Please justify your response

Do you believe that the mathematics curriculum in use in our secondary school is providing students with requisite skills for the workplace?

What should be the future goal of mathematics education in our schools?

What is your vision for the role of mathematics education in general in the Education system of Antigua and Barbuda?

Any last parting word as I bring this dialogue to an end?

Thank you for giving of your time to be a part of my research data collection exercise

Appendix F - Questions Used to Collect Data from Secondary Schools Mathematics Officer

Constructed Questions for Secondary Schools Mathematics Officer (AG)
Has there been any change to the secondary mathematics programme over the past five years?
What do you perceive as the main concern of teachers who teach mathematics in the Secondary schools?
What roles are teachers preparing students to achieve while dispensing mathematics education in Secondary schools' classrooms?
In your opinion is there any connection between classroom mathematics and the career goals of students?
Are there efforts to connect the mathematics taught in school to the real world?
Do you believe sufficient preparation is being made to equip students for the job market? Can you say what you think they are?
Are mathematics topics taught in schools preparing students with skills for the knowledge economy?
As a leader in mathematics education, what in your opinion should be the focus in the future for classroom mathematics lessons?
Are mathematics topics taught in schools preparing students with skills for the knowledge economy?
Anything else you need to expand on here?
What should be the way forward for mathematics education in Antigua and Barbuda?
What would you like to say as a last contribution to this interview?

Questions asked of Secondary Education Mathematics Officer during Interview (2009)

Appendix G - Number of Teachers Trained in Mathematics Pedagogy

Secondary Schools - 2011-12	Total males	Total Females	Totals	Total number of trained teachers 2011-12	Number of teachers trained in mathematics pedagogic skills2011-12
All Saints Secondary	24	42	66	46 70%	1 2%
Antigua Girls High	7	40	47	38/47 81%	2 4%
Clare Hall Secondary	11	42	53	38/53 72%	2 4%
Sir Mc Chesney George's	4	8	12	7/12 58%	0
Jennings Secondary	22	30	52	30/52 58%	2 4%
Ottos Comprehensive	16	43	59	37/59 63%	2 3%
Pares Secondary	9	31	40	30/40 75%	0
Princess Margaret	17	59	76	55/76 72%	1%
Glanville's Secondary	5	13	18	12/18 67%	1 6%
St. Mary's Secondary	3	12	15	10/15 67%	0
Antigua Grammar School	20	25	45	30/45 67%	1 2%
Total	**138**	**345**	**483**	**333/483 69%**	**11/483 2%**

Appendix H - Number of Trained Mathematics Teachers: 2012-13

Secondary Schools - 2012-13	**Total members of staff**	**No. of trained teachers**	**No. of teachers trained in the art of teaching mathematics**
All Saints Secondary	66	51/66 77%	2 3%
Antigua Girls High	47	31/47 66%	1 2%
Clare Hall Secondary	61	40/61 66%	2 3%
Sir Mc Chesney George's	15	9/15 60%	0
Jennings Secondary	54	25/54 46%	2 4%
Ottos Comprehensive	65	'65	2 3%
Pares Secondary	50	26/50 52%	0
Princess Margaret	81	57/81 70%	1 1%
Glanville's Secondary	19	14/19 74%	2 11%
St. Mary's Secondary	*	*	0
AGS	45	36/45 80%	0
Total		**289**	**10 total**

Appendix I - Academic Qualification of Mathematics Teachers

The Table below gives the number and a detailed account of the qualifications of mathematics teachers in government's secondary schools in Antigua and Barbuda.

Categories	Categories
Trained teachers with mathematics as a subject To include: Trained teachers 4 Trained teachers and Level mathematics 2 Trained teacher and mathematics education 1 Trained in teaching secondary school mathematics 1 Trained teacher with mathematics at A' level 1	**Untrained teachers with:** A' levels in mathematics 5 Antigua and Barbuda's state college Certificate 1 No background in mathematics 1 Uncertified 2
First degree in mathematics: Presently in progress (UWI) 1 And teacher trained 1	**Associate degree in:** Business only 1 Mathematics and teacher trained 1 Education – specializing in mathematics and science 1
First degree in mathematics: Presently in progress (UWI) 1 And teacher trained 1	**Masters in:** Business 1 Mathematics and teacher trained 1
First degree in: Accounts 1 Business 1 Mathematics and majoring in physics 1	**First degree in:** Mathematics and chemistry 1 Business administration 1 Computer science 1

Social sciences 1 Theology 1 Biology 1 Information technology and accounts 1 Mathematics and Electrical engineering 1 Accounts and a post graduate diploma in teaching and learning mathematics. 1	Information Technology 1 Law (LLB) and teacher trained 1 Finance 1 Business and teacher trained 1 Education 1 Physics and mathematics 1 The sciences 1

Appendix J - Detailed Account of Qualification of Government's Secondary Mathematics Teachers (2012)

Secondary Schools	Qualification of Teachers 2008-2012
All Saints	BSc. Physics and mathematics Associate degree TT U/W.I. BSC. Mathematics, TT; CXC O' Levels: BA. Religion; BA. Education Mathematics focuses. GCE O' Levels.
Clare Hall	BSc. mathematics; BSc. Engineering; BA accounting and Post graduate Diploma in mathematics; A' Levels CXC certificate; BSc. mathematics and information technology
Jennings	O' levels and Teacher Trained; BSc. Information technology; BA: accounting (2); A' levels. CXC O, level
Ottos comprehensive	Associate degree UWI, TT& CXC O' levels (2 teachers); BSc. Physics and mathematics; BSc. Chemical Technology; BA. Education. BSc; Mathematics in progress.
Pares	BSc: Mathematics; BSc. Physics and mathematics; TT Associate degree. CXC O' levels; CXC O' Levels. Associate degree and teacher trained; CXC O' levels.
Princess Margaret	MA: mathematics; MA: mathematics; BA. Education & PGC/leadership; BA. Administration; BSc. management studies and TT; BSc. mathematics and physics; BSc. Science
Antigua Girls High	BA. Dip Ed.; BA (Law) Associate Degree teaching Mathematics; BA and Teacher Trained; BSc. Mathematics, Teacher Trained; BSc. Mathematics
Antigua Grammar	BSc. and Diploma; BSc. Mathematics and Information technology; Associate degree; A' levels: CXC certificate; BSc. Physics and mathematics; BSc. Mathematics and physics.
Sir Mc Chesney George High	Teacher Trained certificate (2008-presently); BSc. 2008; Teacher trained Certificate; BA Accounts (2011-presently);

Qualification of mathematics teachers in each of the government's secondary schools, 2008-2012

Appendix K - Video Showing Some of the Work Sites Visited and Questions Posed to Participants

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