A Study of Dominican Secondary Mathematics Teachers' Explanations of Factors Affecting Their Instructional Practices

by

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Abstract

The purpose of this study was to gain an explanation from teachers on any relationship which exist between students' performance on the Caribbean Examination Council (CXC) mathematics examination and Dominican secondary teachers' mathematical knowledge, frequency of use of 12 teaching strategies, and beliefs about the teaching of mathematics.The study was conducted using Creswell's (2013) explanatory sequential mixed methods design which included a quantitative data collection phase which was used to inform a qualitative data collection phase.

Phase one, the quantitative phase, was a survey of all fourth and fifth forms teachers (N=47) in Dominica. The analysed results of the survey were used to prepare the questions used in data collection in phase two. In phase two of this study, six highly experienced teachers from the surveyed participants participated in a group discussion. The group discussion was used to provide a data source used to develop teachers' explanations of any relationship, or lack of, that they observed between students' CXC mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. Group discussions were audiotaped with relevant sections transcribed and used in the presentation of results.

The results from the quantitative analysis and the qualitative analysis were synthesized to answer the research question: *In what ways will Dominican secondary mathematics teachers explain any relationship between students' CXC performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?* Focus group participants offered several explantions for their observations of possible relationships between students' CXC

mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. Group participants articulated that most Dominican secondary teachers possessed a good grasp of the mathematics content needed to teach students preparing for CXC mathematics, but, in general did not frequently use recommended strategies nor did they demonstrate the ability and/or willingness to allow their teaching practices to reflect what they believed are sound pedagogical practices.

Preface

This thesis is an original work by Christopher Charles. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name "Performance in Mathematics: A Dominican perspective", I.D. Pro00045612, 10/29/2014.

Dedication

This thesis is dedicated to my wife – Norma Durban-Charles, my daughter – Carissa Charles, and my son – Caeden Charles who provided the emotional support and stability I needed to see this graduate program through. To them I will be eternally grateful.

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With God, all things are possible; I owe it all to God. He provided the opportunity, he put in place the many individuals who assisted me in one way or another, he protected me through this journey, and he blessed me with the intelligence I needed to take the program of study from start to finish. I thank you Lord.

I thank the Organisation of American State (OAS) and the University of Alberta for providing the financial support needed to see me through this period of study. Special thanks to Dr Lynn McGarvey at the University of Alberta with who I worked at as teaching/research assistant.

Without the guidance of my program supervisor and the rest of my thesis committee, completing this thesis would not be possible. Heartfelt thanks go out to Dr Florence Glanfield – my program supervisor, Dr Elaine Simmt and Dr Jose da Costa who completed my committee. Your guidance and contributions to my professional development will always be appreciated.

Mention must be made of Mrs Windith Henderson who did not only inspire me to pursue further studies in my field but also provided advise and information on funding opportunities. Along with Dr Francis Severin at the University of the West Indies and Ms Loise George, Mrs Henderson also provided a letter of recommendation which facilitated my acceptance and subsequent entry into graduate school. I say thanks to these three Dominicans, the confidence you showed in me and the assistance you provided me will never be forgotten.

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Chapter 1: Introduction

The General Proficiency Mathematics examination is offered in January and May/June each year. There was a candidate entry of approximately 90 100 in May/June 2014 and 50 per cent of the candidates earned Grades I–III. The mean score for the examination was 75 out of 180 marks (Caribbean Examination Council, 2014).

This chapter presents aspects of the study that are critical to a thorough understanding of the thesis. Presented is a detailed account of the background of the study which includes the environment in which the study was undertaken, the knowledge and experiences of the researcher, and the history and expectations of CXC mathematics – the basis by which students' performances were judged. Also included are details of: the study aims and objectives, the questions that the study aimed to answer, the study design, a rationale for the study, and a summary of chapters. The background is presented first.

Background

The above quote is an extract taken from the Caribbean Examination Council (CXC) mathematics report following the May/June 2014 regional examination. It is not unlike previous years' report, in that, over the last ten years (2004 – 2013) approximately 40% of candidates each year succeeded at obtaining grades I, II, or III – CXC passing grades (Ministry of Education, 2012; 2013a). This very moderate rate of success is experienced throughout the Caribbean region with Dominica, my homeland, being no exception.

The Environment.

Dominica is a small, developing country located in the Eastern Caribbean with fifteen secondary schools, most of which are coeducation, public institutions. Of the fifteen secondary schools in 2014, there were two fully privately funded secondary schools and four publicly funded but privately governed secondary schools in Dominica. Of the four publicly funded schools, two are single sex schools and are located in the capital city – Roseau. All other secondary schools, both public and private, are coeducational. Regardless of the school type or governance structure, however, teaching staff at all schools are made up of a mixture of males and females and my knowledge of the mathematics environment in Dominica indicates that the secondary mathematics curriculum is taught by a near fifty/fifty (50/50) split of male and female teachers.

As of August 2013, most teachers' highest level of qualification in mathematics was an A-level certificate provided by Cambridge England, or/and an associate degree in mathematics from the Dominica State College; very few mathematics teachers had mathematics or mathematics education degrees (Ministry of Education, 2013b). This lack of higher mathematics qualification among secondary mathematics teachers concerns policy makers and, in recent times, steps have been taken to upgrade the mathematics qualification of teachers. Mathematics teachers were encouraged to pursue higher education in mathematics and from 2007, incentives in the form of scholarships, were given to some in-service mathematics teachers to pursue undergraduate studies in mathematics education at the University of the West Indies (UWI). I was a recipient of one such scholarship and the policy was, I believe, a step in the right direction.

Increasing teachers' mathematics qualification is a step in the right direction, because several studies (Baumert et al., 2010; Watson and Harel, 2013; and Even, 1993) show a direct and positive correlation between teachers' mathematics qualifications and students' performance on examinations. However, it is just a small part of the solution to the prevailing problem of poor performance on CXC mathematics examinations since the correlation between teachers' mathematics content knowledge and students' performance, although positive, is shown to be weak (Baumert et al., 2010; Watson and Harel, 2013; and Even, 1993). Also, I believe the problem goes deeper than teacher qualification, because, besides the improvement in teachers' qualification, Dominican students' performance on CXC mathematics examinations continued to spiral downwards (Ministry of Education, 2013a) (see Appendix 1). Hence, to uncover a more profound, practical and lasting solution, a more in-depth investigation of the problem is needed. My study was a step in that direction.

The Researcher.

As a secondary mathematics teacher for over twenty (20) years, I lived through the frustration, doubts, and anger of principals and supervisors who wanted better results but whom, in retrospect, I realised were at their wits end wondering how to approach Dominica's mathematics problem. As a young, untrained, and inexperienced teacher, I was part of the problem. My role within and my contribution to the problem changed as I graduated into a trained, matured, and more experienced teacher. As a Numeracy Specialist within the Ministry of Education, I grew more and more concerned and felt more and more inadequate in providing guidance to mathematics teachers. It is these experiences that brought me to the University of Alberta and to this thesis.

I started my mathematics teaching career at the St. Andrews' High School (SAHS) in September of 1990 at the age of twenty. SAHS was (its doors were shut in 2006 giving way to the North East Comprehensive School) a coeducational institution located in a rural part of Dominica and served six rural communities. In my first year of teaching at SAHS, I taught mathematics to three grade levels: first form (grade 8), second form (grade 9), and third form (grade 10). The struggle had started. I was young, untrained, inexperienced, and above all, believed I knew how to teach CXC mathematics because I had just completed an advance course (A – level) in mathematics. Three years of teaching, however, soon taught me that I needed more and when the opportunity came in 1993 I travelled to New Mexico to undertake undergraduate studies in mathematics education at New Mexico State University (NMSU).

The program of study I undertook at NMSU was a joint venture between NMSU and the Dominica Teachers' College (presently the Dominica State College) which afforded me a certificate to teach mathematics at the secondary level. In the program I undertook courses in mathematics, mathematics pedagogy, and some general education foundational courses. The program lasted two years: eight months (two semesters) at NMSU followed by twelve months (three semesters) in Dominica. The Dominican leg involved course work regarding issues in the Dominican classroom and a supervised practicum period. I completed the program in 1995 and thereafter was certified in Dominica as a qualified teacher. With my new qualification, I continue to teach mathematics at the St. Andrews' High School.

Not only did I continue to teach mathematics but soon after becoming qualified I was given the position of head of the mathematics department at SAHS. As head of mathematics, I was partly responsible for supervising the work of the other mathematics teachers at the school. Included in my supervisory duties were: monitoring and providing feedback on teachers' lesson plans, unit plans, and exams; monitoring and providing feedback on teachers' classroom practices; identifying training and other immediate needs of the mathematics department; holding timely departmental meetings; and representing the department at school's management meetings. I continued to perform these duties and more at the North East Comprehensive School (NECS) after the doors of SAHS were shut in 2006. I also took with me to NECS experiences gained as deputy principal from SAHS.

I served as deputy principal at SAHS the year before its doors were closed and had the privilege to act as principal several times during that period. My positions were carried over to NECS where I served as assistant principal, head of mathematics department, and mathematics teacher. As part of my added responsibilities, I facilitated workshop sessions for younger teachers of mathematics and assisted principals on matters of discipline. I also served, as a member of a body of mathematics educators, with the mathematics learning support office in the Ministry of Education. This body gave rise to the National Association of Mathematics Educators (NAME) of which I was the first president.

NAME was registered in Dominica September of 2011 and has as its motto: *Empowering Mathematics Educators.* NAME at its core has a vision to increase the confidence, zeal, and effectiveness of mathematics educators in Dominica. I became the first president of NAME because my beliefs were inseparable from that of the association. In my stint as president, the constitution of NAME was developed and registered. By then I had completed studies which led to a B.Ed. in secondary mathematics education.

At the same time, between September 2007 and June 2010, I read for a B.Ed. in secondary mathematics education at the University of the West Indies, open campus. In this program of study I was exposed to several areas of advanced mathematics content, mathematics pedagogy, education foundational courses, and technology in education. To cap this program, I conducted an action research study on one aspect of my teaching and presented the findings, as a written document, to the University of The West Indies. The research was part of a supervised practicum period and focused on cooperative learning in my mathematics classroom. This qualification and the above mentioned experiences propelled me into the Ministry of Education.

In 2010, the government of Dominica, through the Ministry of Education enhancement unit, embarked upon an education enhancement project in which numeracy improvement was a major component. The numeracy component was awarded to a consultancy firm from the United Kingdom (G2G Consultants) with two local persons attached as Numeracy Specialists. I served in one of these two positions for three years and during that period gained some invaluable experiences in regards to mathematics education.

As a numeracy specialist, I worked alongside the G2G main consultant providing training to teachers of mathematics; visited, observed, and provided feedback to teachers; and prepared and demonstrated model mathematics lessons. I was also present in many meetings between the consultants and ministry officials when findings from the consultancy were presented and discussed. These encounters further opened my eyes to the frustrations and concerns of education policy makers in regards to Dominica's mathematics problems.

Consequently, I joined a mathematics taskforce to look into factors affecting mathematics performance in Dominica and in September 2013, I joined the band of scholars looking for research answers. In this study I focused on teacher/teaching factors affecting the teaching and learning of mathematics in Dominica, bringing with me the knowledge and experiences gained from my professional life. CXC mathematics examination is part of that knowledge.

CXC Mathematics Examination.

The mathematics examination taken by secondary school leavers in Dominica and the wider Caribbean is administered by the Caribbean Examination Council (CXC) in May/June each year with a second sitting in January the following year. This examination is distinct from other CXC schools' examinations and is referred to as the Caribbean Secondary Education Certificate (CSEC). As such, all further references to CXC examinations in this thesis refer to this CSEC examination. In January, individuals take the examination as private candidates, therefore, January results have no bearing on schools' mathematics results, hence, did not form part of the data in this study. CXC data referred to in this study came only from May/June examinations and to better understand its impact, three aspects of CXC mathematics are discussed: its history and structure, the syllabus, and the examination and what it means for Dominican secondary students.

History and structure.

The Caribbean Examination Council has been around since 1972 when it was instituted under an agreement by Caribbean governments. Over forty years ago, the council was mandated to prepare and administer appropriate and relevant regional examinations, and award certificates and diplomas as necessary (Caribbean Examination Council, n. d). From its inception, the council has been administering examinations to secondary school leavers in some subject areas; the mathematics examination was present from inception. As the years passed by, examinations in more subject areas were added, different type of examinations were added, and CSEC mathematics examination structure changed.

A major change in the structure of CSEC mathematics examination was the removal of the basic proficiency examination. At inception, two proficiencies – basic and general were administered. The basic proficiency examination was geared towards secondary school leavers who desired to join the work force. The exam sampled content from the core mathematics syllabus and the test items were straightforward in design (Caribbean Examination Council, n. d). The general proficiency paper, on the other hand, was geared towards students wishing to further their education. Hence, the items were more challenging than those on the basic proficiency paper and were aligned with matriculation requirements of regional universities (Caribbean Examination Council, n. d). The structure of this examination changed in 1998 to feature a single general proficiency paper, done by all registering secondary school leavers. The present structure of this examination and the syllabus which drives it will be discussed in subsequent sections. The next paragraph gives a brief description of the structure of the Caribbean Examination Council.

CXC is a regional organisation governed by representatives from leading Caribbean institutions. Following is a list of representatives which constitute the council: the Vice Chancellor of the University of the West Indies; the Vice Chancellor of the University of Guyana; three representatives of the University of the West Indies appointed by the Vice Chancellor of the University of the West Indies; one representative of the University of Guyana appointed by the Vice Chancellor of the University of Guyana; two representatives appointed by each of the participating governments of Barbados, Guyana, Jamaica and Trinidad & Tobago and one representative appointed by each of the other participating governments; one representative of the teaching profession appointed by each National Committee from among its members, of which there are sixteen (Caribbean Examination Council, n. d.). The duties of these representatives are coordinated by the registrar and pro-registrar through two committees and a sub-committee – Administrative and Finance Committee (AFC), the School Examinations Committee (SEC) and its Sub-Committee (SUBSEC) (Caribbean Examination Council, n. d.). SEC and SUBSEC oversee the development of subject syllabuses which includes the mathematics syllabus used in all secondary schools in Dominica.

The syllabus.

The mathematics syllabus used in Dominica's secondary schools, and secondary schools in the wider Caribbean, is developed by CXC using the expertise and experience of Caribbean educators and private sector specialists in consultation with hiring firms and industries in the Caribbean (Caribbean Examination Council, n. d.). This cross section of stakeholders work towards ensuring that the content of the mathematics syllabus is relevant to the needs of the Caribbean community and other western societies. In doing so, the rationale and aims of the syllabus; and general and specific objectives of content strands are articulated. The syllabus also outlines: the core topics and topics relevant to individuals looking to further their studies in related fields; how the examination is formatted – multiple choice and longer type questions, time and mark allocations, number of items sampling the content strands; profile dimensions – knowledge, comprehension, and reasoning and the number of marks allocated to each; regulations for candidates sitting the examination – private and resit candidates; mathematics symbols used in examinations; formulae provided during mathematics examinations; a policy statement regarding the use of calculators during examinations; a recommended list of textbooks; and a glossary of terms relevant to the content covered in the syllabus (Caribbean Examination Council, 2010).

The bulk of the syllabus, however, presents the content strands to be covered by secondary students. Ten (10) strands, arranged as sections, span the syllabus: Section 1 – Computation; Section 2 – Number Theory; Section 3 – Consumer Arithmetic; Section 4 – Sets; Section 5 – Measurement; Section 6 – Statistics; Section 7 – Algebra; Section 8 – Relations, Functions and Graphs; Section 9 – Geometry and Trigonometry; Section 10 – Vectors and Matrices (Caribbean Examination Council, 2010).

Each strand is divided into general objectives and specific objectives. General objectives are knowledge, skills, and attitudes desired in today's society while specific objectives are content specific knowledge, skills, and attitudes to be taught in the classroom. Specific objectives in Algebra; Relations, Functions and Graphs; Measurement; Geometry and Trigonometry; and Vectors and Matrices are further broken into core and optional objectives (Caribbean Examination Council, 2010). Objectives in all other strands are core objectives. Core objectives comprise of the knowledge, skills, and attitudes fitted for all students while optional objectives are designed for students wishing to pursue further studies in mathematics and related fields (Caribbean Examination Council, n. d). Further, most specific objectives are accompanied by relevant contents that are expected to be taught to students and tested in the May/June and January mathematics examinations.

The examination.

The mathematic examination comprises of two papers: paper 01 - multiple choice questions, based on the core objectives of the syllabus and paper 02 – essay (problem solving) type questions, based on both the core objectives and optional objectives (Caribbean Examination Council, 2010). Both papers are taken on the same day at centres in different locations around Dominica – usually at the students' respective schools or at a neighbouring school. These centres are manned by a CXC contracted invigilator who is assisted by teachers and/or other outside persons because of the large number of candidates who usually take the mathematics examination at any one centre.

Mathematics examinations start at nine in the morning (09:00) with paper 02. Canadidates have two hours and forty minutes to complete ten out of eleven structured and problem solving type questions. These eleven questions are divided into two sections. Section 1 is comprised of eight compulsory questions sampling the core objectives of the syllabus (see *Table 1.1* for a description of the 8 questions and the marks connected to each question). Section 1 samples the syllabus as follows (Caribbean Examination Council, 2010):

Content strands	**No. 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 (a question set on a combination of core objectives)	10
Total	**90**

Table 1.1: Section 1 of paper 02 sampling of core objectives in content strands

Section 2 is comprised of three optional questions sampling the core and optional objectives of the syllabus. Students are expected to answer any two of the three optional questions (Caribbean Examination Council, 2010). Each question is allocated fifteen (15) marks. One question is set on each of the following combinations of strands: algebra, and relations, functions and graphs; measurement, and geometry and trigonometry; and vectors and matrices (Caribbean Examination Council, 2010). Paper 02 of the examination totals one hundred and twenty (120) marks which constitutes two thirds of the marks allocated to the entire examination. Paper 01 contributes the other one third.

Paper 01 is taken at 13:00 hour (1 p.m.) on the same day, after candidates have taken a lunch break. Candidates are required to answer sixty multiple choice questions by filling grids on an answer sheet. One mark is given for each correct response and no mark is deducted for incorrect responses. The multiple choice items sample the core objectives of the syllabus as described in *Table 1.2* (Caribbean Examination Council, 2010):

Content strands	No. of marks
Computation	6
Number Theory	4
Consumer Arithmetic	8
Sets	4
Measurements	8
Statistics	6
Algebra	9
Relations, Functions and Graphs	6
Geometry and trigonometry	9
Total	**60**

Table 1.2: Paper 01 sampling of core objectives in content strands

Paper 01 is graded by machines at CXC head office in Barbados while paper 02 is graded by mathematics teachers across the Caribbean region. Grading standards, cut-scores, and grades are determined by the relevant committee of the Caribbean Examination Council (Caribbean Examination Council, n. d).

CXC reports a criterion reference approach to their examinations which can be seen in the way objectives are sampled in its CSEC mathematics examination (Caribbean Examination Council, n. d). As such, CXC is “concerned with whether or not candidates have reached established levels of mastery” (Caribbean Examination Council, n. d, n. p). That is, examinees’ performances are compared with “pre-set standard judged to be adequate for the award of particular grades" (Caribbean Examination Council, n. d, n. p). CXC also claims, however, that after the grading process grades may be adjusted after they are compared to candidates' performances from previous sittings. These grades are reported using two six point grading scales – overall grades (I – VI) and profile grades (A – F). Overall grades have the following meanings (Caribbean Examination Council, n. d):

Overall grades	Standard
I	Candidate shows a comprehensive grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
II	Candidate shows a good grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
III	Candidate shows a fairly good grasp of the key concepts, knowledge, skills and abilities required by the syllabus.
IV	Candidate shows a moderate grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
V	Candidate shows a very limited grasp of the key concepts, knowledge, skills and competencies required by the syllabus.
VI	Candidate shows a very limited grasp of the key concepts, knowledge, skills and competencies required by the syllabus.

Table 1.3: Explanation of CSEC overall grades

Explanations for the grading profiles: Knowledge – "items that require mainly recall of rules, procedure, definitions, and facts"; Comprehension – "items that require algorithmic thinking that involves translation from one mathematical mode to another"; and Reasoning – items that require translation of non-routine problems, combinations of algorithms, use of algorithm in reverse order, generalisations from given data, justification of results, and analysing and synthesizing (Caribbean Examination Council, 2010, p. 4) are presented below.

Profile grades	Standard
A	Outstanding
B	Good
C	Fairly Good
D	Moderate
E	Weak
F	Poor

Table 1.4: Explanation of CSEC profile grades

These profile grades along with the overall grades appear on student certificates and determines a student's future endeavours in mathematics and its related fields. In that regard, CXC recommends that grades I – III satisfy matriculation requirement for most four-year university programmes and grades I – IV satisfy requirement for entry-level employment(Caribbean Examination Council, n. d). In my experience however, despite CXC recommendations, grade IV is hardly recognised by the Dominican public.

Aims of the Study

Given the importance placed on CXC mathematics in the Dominican society, my experiences in the mathematics classroom, and a great sense of wanting to provide assistance to existing and furture mathematics teachers, I saw the need to know what currently exists in the mathematics teaching community in Dominica. I realised that it is only through proper analyses of existing factors that research can be used to inform and hopefully bring about meaningful change in the teaching practices of Dominican teachers. As such, this study conducted between September 2014 and February 2015 aimed to see how teachers explained any relationships between students' performances in CXC mathematics examinations and fourth and fifth forms mathematics teachers' mathematical knowledge, frequency of use of 12 recommended teaching strategies, and beliefs about the teaching of mathematics.

Objectives of the Study

As a scholar and educator, I came to realise the importance of research both as professional development and as a means of contributing to my professional world. This journey, moving my thesis from proposal to presentation, marked an initial step in what I hope will be a life-changing experience. Put explicitly, the primary objectives in undertaking this project were to acquire and/or hone necessary research skills and to compile and document salient teacher-factors that may be affecting Dominican secondary students' performance in mathematics. The second objective is particularly important because in Dominica little to no structured investigation had been conducted to look into ways that teachers explain any relationship between students' performance in CXC mathematics and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. Now that this research project is completed, the data will hopefully provide the foundation for further research and/or apprise Dominican education officials and policy makers, mathematics teachers and principals, and all other stake-holders, of the quality of teaching in Dominica's secondary mathematics classrooms. In other words, my hope is that this document will not only find space in the University of Alberta database or on bookshelves, but will find its place in the work of other scholars, Dominican and others, and in the actions of change makers.

Research Question

In this quest, I searched for insights into the research question:

In what ways will Dominican secondary mathematics teachers explain any relationship between students' CXC mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?

The following questions were used to focus the collection of quantitative data:

1. What mathematical knowledge do Dominican mathematics teachers take into secondary classrooms?
2. How frequently do Dominican secondary mathematics teachers employ recommended teaching strategies in their classrooms?
3. What are Dominican secondary mathematics teachers' beliefs about the teaching of mathematics?

Information in regards to these questions was collected through a questionnaire in which twelve recommended strategies and fourteen belief statements were highlighted, and teachers' qualifications and experiences were solicited. The analyses of the answers to these questions were used to develop three questions which focused the collection of qualitative data.

The following questions were used to focus the collection of qualitative data:

1. How will Dominican secondary teachers explain the lack of correlation between Dominican students' CXC performance and their teachers' content knowledge, pedagogical content knowledge, and mathematical knowledge?

2. Since our teachers have been using all of the recommended teaching strategies with high frequency, how will Dominican secondary teachers explain the dismal CXC mathematics performance over the years?
3. How are Dominican secondary teachers' beliefs about the teaching and learning of mathematics reflected in their teaching practice?

During the group discussion, these questions were rephrased, slightly, to address the participating teachers directly.

Overview of Study Design

An explanatory sequential mixed methods design was used in this study. This means that a qualitative phase followed an initial quantitative phase during data collection. The results of the quantitative phase were use primarily to inform the questions used to focus data collection in the qualitative phase, thus, integrating both sets of data. However, in the integration greater priority was given to the qualitative phase to answer the main research question. According to Creswell (2013), explanatory sequential studies are used when a qualitative phase is needed to explain the findings from a quantitative phase. Creswell further argued that the priority given to the different phases is dependent on the researchers' aims and purpose for the study.

Rationale for the Study

The effects of mathematical knowledge and sound pedagogical practices are well documented in literature (Baumert et al., 2010; Watson & Harel, 2013; Even, 1993; D'Ambrosio, Johnson, and Hobbs, 1995), however, few studies of this nature were based in the Caribbean region and none, recorded, was based in Dominica. Dominica is part of the global community with scholars attending colleges and universities all over the world and it is important that Dominicans secondary mathematics experiences form part of the grand narrative. It may just provide the foundation that interested scholars need to conduct further studies in the Caribbean region. It is even more important that the mathematics classroom experiences of Dominican students be compared with mathematics classroom experiences of their counterparts around the world. This will create an opportunity for policy makers, teacher educators, and teachers to rethink and reshape their craft; allowing for improved mathematics performances in Dominican students.

The rethinking and reshaping of one’s practice, however, must be based on clear evidence of what is right and wrong with their practice and changes must be influenced by tried and proven practices. Such evidence can only be uncovered through empirical studies; this study provides empirical evidence on Dominica’s secondary mathematics teachers’ mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematics. Evidence from this study is considered against relevant existing literature and can inform future policies and practices in regards to mathematics education in Dominica. Evidence in this study were compared with other studies such as Davis and Renert (2014), Ma (1999), Garofalo (1989), and the work of D’Ambrosio, Johnson, and Hobbs (1995), to name a few, all of which provided invaluable insights into the field of mathematics education. Aspects of these studies influenced the framing of this study. Consequently, this study provides a solid foundation on which further studies into the knowledge and practices of Dominican mathematics teachers can be built.

Summary of the Chapters

This study is organised in chapters with each chapter presenting a different aspect of the study. Following are brief summaries of each chapter presented in the same order that they are arranged in the study.

Chapter one, the introductory chapter, presents an overview of the study background, aims and objectives, research question, and study design. In the background I detailed the environment in which the study was conducted, I positioned myself as researcher, and provided a comprehensive detail of the benchmark (CXC mathematics) by which students’ mathematics performances are judged. A rationale for the study is also included.

Chapter two presents reviews of relevant literature. The reviews focused on the effects of mathematical knowledge and teaching strategies on students’ mathematics performance, and how beliefs about the teaching of mathematics affect teachers’ practices. The chapter shows that teachers’ mathematical knowledge is positively correlated with students’ mathematics performance, highlighted twelve recommended teaching strategies in relation to the teaching and learning of mathematics, and pointed to some unhealthy beliefs and beliefs based on constuctivism.

Chapter three outlined the explanatory sequential mixed methods design and discussed why it is particularly suited to this study. Specific details of the recruitment process for the study are outlined and explained. Particular attention to ethical consideration has been addressed in this chapter. Quantitative and qualitative data collection techniques are also addressed. Data analyses, including quantitative, qualitative, and the integration of data are described and discussed.

Chapter four details and discusses the results of the study. Results of both the quantitative analysis derived from the survey data and the qualitative analysis derived from the group discussion are presented. The chapter also presents discussions which integrates the results of the quantitative and qualitative analyses. Integration of these analyses revealed a deficiency in the exposure of Dominican secondary students to recommended teaching strategies related to mathematics teaching and learning.

Chapter five concludes the thesis. It offers discussions on the study's empirical findings, theoretical and policy implications, and offers two suggestions for further study – research into ways of improving teachers' mathematical knowledge and research into CXC mathematics examination. The chapter revealed that Dominican teachers possess a fair grasp of the mathematics content needed to teach students preparing for CXC mathematics, but are deficient in pedagogical content knowledge and either lack the ability and/or willingness to allow their teaching practice to reflect what they believe are sound pedagogical practices. The chapter concluded that a limited exposure to a variety of recommended teaching strategies, which goes contrary to teachers'stated beliefs, but fuelled by a weekness in teachers' pedagogical content knowledge, may be related to students' poor performance on CXC mathematics examinations.

Chapter 2: Literature Review

This chapter presents an overview of the literature related to this study. Given the large volume of related literature that is available, it is beyond the scope of this thesis to present and discuss all available literature. The literature reviewed and presented in this thesis, however, was used to address the main areas of interest and issues pertinent to the study.

Addressed in this literature review are the effects that teachers' mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematics had on students' performance in mathematics. The review of literature related to mathematical knowledge is presented first, followed by the review of literature related to teaching strategies with the review of literature related to teachers' beliefs about the teaching of mathematics coming last. Each review begins with a brief explanation of the related concept – mathematical knowledge, teaching strategy, and beliefs about the teaching of mathematics respectively and provides reviews of several articles/works related to the concept in question. This literature review helped to position this thesis and provided the lenses through which empirical findings of the study were discussed. The chapter ends with a summary tying the findings from the various pieces of literature reviewed in relation to the study.

To obtain the articles/literature for review, manual searches of journals, resource books, and other printed materials were conducted. Database searches included, but were not limited to: Eric, Education Research Complete, SAGE online, and Proquest. Resources such as the University of Alberta libraries and the World Wide Web were also accessed. Google Scholar, on the World Wide Web, was particularly used for initial searches to point me to articles that were then accessed through the above mentioned databases.

To focus my database and web searches, key words and phrases including 'pedagogy', 'pedagogical knowledge', 'pedagogical content knowledge', 'teaching' 'teaching strategies', 'mathematics teaching strategies', 'advance mathematics knowledge', 'mathematics beliefs', 'beliefs about mathematics teaching and learning', and several other combinations of these words and phrases were used. Some searches returned e-copies of relevant articles and others led to books that were borrowed from the university libraries. Following are the details of the literature reviewed.

Mathematical Knowledge

In this study, mathematical knowledge has two dimensions: knowledge of mathematics concepts – mathematics content knowledge (CK) and knowledge of recommended practices that should be employed in the teaching of mathematics – mathematics pedagogical content knowledge (PCK). Both pieces of knowledge are critical to the effective teaching of mathematics (Davis & Renert, 2014). Mathematics contents, beyond secondary school, are usually taught in faculties of arts and sciences at colleges and universities while mathematical pedagogical contents are taught in faculties of educations. Seldom are both pieces of mathematical knowledge taught in the same faculty and thoroughly integrated into the same teacher education program (Proulx & Simmt, 2011). In this context thorough integration refers to mathematics content taught in conjunction with and in context of teaching. This lack of integration is evident even in Bachelor of Education program, such as the B.Ed. in secondary mathematics education that I completed at the University of the West Indies, open campus. In that program, the mathematics courses were all taught as pure content courses while the mathematics pedagogy courses were taught separately and relatively empty of mathematics content. In this study, the effects of both pieces of mathematical knowledge are under investigation and the remainder of this section is devoted to examining how content knowledge and pedagogical content knowledge have affected the teaching of and students' performance in mathematics.

Mathematics teachers, both certified and uncertified, must have a good grasp of the mathematics content they are called upon to teach. The question, however, is how much mathematics content is required if students are to acquire a good understanding of mathematical concepts. A good understanding in this context refers to students' abilities to solve both routine and complex application questions and to successfully use learned concepts for future learning, a notion Tall (2013) refers to as met-before. In the context of teaching mathematics at the secondary school level: Does university acquired content matter? Research suggests that teachers with advanced (university acquired) mathematics content knowledge positively affect students' mathematics performance at the secondary level. Research also shows, however, that advanced mathematics content knowledge is an essential but not sufficient criterion for the effective teaching of mathematics (Davis & Renert, 2014).

This begs the questions: (a) what does effective teaching of mathematics looks like? And (b) what knowledge is needed to teach mathematics effectively?

According to Ma (1999), effective teaching of mathematics refers to teaching which goes beyond showing students how to solve routine mathematics problems through the use of well-practiced algorithms, but also allows students to develop an understanding of why these algorithms work, and how they can be connected to other mathematics concepts. For effective teaching of mathematics, research suggests that teachers require (a) sound mathematics pedagogical content knowledge, and (b) mathematics content knowledge beyond what they teach in their individual classrooms. Claims, which support this notion, argue that it is teachers' pedagogical content knowledge that has the greater effect on students' mathematical thinking and allow teachers to provide the necessary support to students experiencing difficulties (Baumert et al., 2010; Watson & Harel, 2013; Even, 1993).

Baumert et al. (2010) support the view that advanced mathematics content knowledge (CK) has a positive impact on students' performance. According to Baumert et al., teachers with advanced CK are better able to align content materials with the curriculum and hence better able to shape students' learning. The study also reported that advanced CK by itself, however, has little or no impact on neither "cognitive activation nor individual learning support" (p. 164) teachers are called upon to provide when learning difficulties arises and that "pedagogical content knowledge (PCK) has greater predictive power for student progress" (p. 164). However, the study noted that PCK is expressly tied to CK. Hence, the positive contribution of teachers' CK on students' mathematics performance cannot be ignored.

Watson and Harel (2013) also concluded that teachers' advanced CK positively influences students' mathematics performance, in that, teachers are better able to develop students' understanding of relevant, underlying mathematics structures, prepare students for future mathematics in relevant areas, and challenge gifted students in mathematics beyond the current content scope. These findings were derived from an observational study conducted with two mathematically well-qualified and experienced teachers teaching at middle and secondary schools. The study investigated how the teachers' "personal mathematical knowledge was manifested in their teaching" (p. 154), and expressly stated, "this article therefore supports the importance of mathematics teachers having personal mathematical knowledge significantly beyond the level at which they are teaching" (p. 166). Like the Baumert et al. (2010) study, however, the teachers involved in this study were highly experienced, which suggests that they may also have had good PCK which could have strongly influenced their teaching and, thus, their students' performances. Therefore, for further insight, I turn to a study where the mathematics knowledge of pre-service secondary teachers was investigated.

Even (1993) conducted a study with 162 prospective secondary mathematics teachers who were attending several mid-western universities in the United States and who were in the last stages of their teacher preparation programs. This study investigated these pre-service teachers' CK and its interrelations with PCK in the content area of functions. The study was administered in two phases over a one-year period in which data was collected from participants, using questionnaires and interviews designed to solicit their CK and PCK of functions. Even found that, although these pre-service teachers had all taken advanced courses in functions, their CK of functions was not secure. Most of these pre-service teachers had difficulties defining a function, explaining the defining attributes of a function, and representing functions appropriately. The article, in fact, expressly stated: "their [pre-service teachers] conceptions were similar to [secondary] students' conceptions" (p. 111). These were pre-service teachers, with "advanced" CK as determined by major universities, showed conceptual understanding no different from the students they were to teach. This begs the question: Will advanced CK really make a difference in students' performance? In the search for answers and further insights, I turn to the report of the National Mathematics Advisory Panel (2008).

In its final report of 2008, the National Mathematics Advisory Panel (NMAP) reported that teachers' mathematical knowledge was estimated in three different ways across research reviewed in an effort to understand the relationship between teachers' CK and students' mathematics performance. These were: "certification, courses completed, and direct tests of teachers' knowledge of mathematics" (p. 35). Although the report stated that it was not fully satisfied with the reliability of some of the research reviewed, the report did state that "at the secondary school level, there appears to be some effect of teachers' content knowledge, on students' mathematics performance, when it is measured in terms of teachers' course-taking" (p. 36).

The primary mathematics classroom is not my focus of attention in this study; hence, my choice of articles so far has focused primarily on the relationship of secondary teachers' CK with students' performance. What happens at the primary school level, however, is very important because it is at the primary school level many of the mathematical foundations are laid (Tall, 2013). Given the influence of primary mathematics education on secondary mathematics teaching, I am forced to take a brief look at how content knowledge impacts mathematics performance at the primary school level.

Hill, Rowan, and Ball (2005) studied elementary teachers and students and found that teachers' mathematical knowledge for teaching positively predicted student gains in mathematics achievement during the first and third grades. Teachers and students from one 115 elementary schools participated in Hill, Rowan, and Ball's three year study which reported that CK "had a positive effect on student gains in the first grade suggests that teachers' content knowledge plays a role even in the teaching of very elementary mathematics content" (p. 399). On average, first grade students were reported to have "gained nearly fifty-eight (58) points on the Terra Nova scale", while "the average third grader gained thirty-nine (39) points" (p. 391).

Although the findings from a single study are not conclusive evidence to say that advanced CK is as important at the primary level as it is at the secondary level, these findings indicate that teachers need to have content knowledge beyond the scope for which they are called upon to teach. This seems to be important at both the primary school and secondary school levels. My experience working with mathematics teachers at the primary level and the secondary level supports this assertion. Working as a numeracy specialist with primary and secondary teachers for three years, I have seen teachers struggle to teach basic mathematics concepts, not because they cannot do the mathematics but because they did not understand the underpinnings of the concepts. My experience, along with the above reviews, seem to point to the fact that content knowledge beyond what teachers are called upon to teach is necessary for the effective teaching of mathematics and impacts student performance. Baumert et al. (2010), Watson and Harel (2013), and Even (1993), however, also indicated that while content is necessary, pedagogical content knowledge is a critical factor in the teaching of mathematics if students are to reap maximum benefits from teachers' classroom practices.

Teaching Strategies

Teaching strategies are methods and procedures used by teachers in their quest to help students develop into independent, strategic learners (Alberta Learning, 2002). The aim in using strategies in teaching is to allow students to independently select the most suited methods and procedures when confronted with problems which they are or may not be familiar with. When students reach such a stage in their development, "these strategies become learning strategies" (Alberta Learning, 2002, p. 67) and students are then able to reap maximum benefits from teachers' classroom practices. Alberta Learning (2002) argues that teaching strategies can: "motivate students and help them focus attention", "organize information for understanding, and remembering", and "monitor and assess learning" (p. 67). Put differently, effective teaching strategies place students in learning environments where they are encouraged to think and act creatively, take responsibility for their learning, and develop conceptual understanding. These can be achieved if students are exposed to a variety of instructional approaches, learning materials, appropriate support, and learning tools (Alberta Learning, 2002). This is in keeping with Even (1993), Baumert et al. (2010), and Watson and Harel (2013), who all indicated that while teachers' mathematics content is vital for successful teaching and learning, it is teachers' pedagogical content knowledge which has the biggest impact on learning. Such arguments speak to the significance of teachers' classroom actions and mandate a closer look at strategies employed in the teaching of mathematics. In the context of this study, twelve strategies recommended by D'Ambrosio, Johnson, and Hobbs (1995) for the effective teaching of mathematics are reviewed and discussed.

It is important to note that, in teaching in general and in the teaching of mathematics in particular, no single strategy always works; rather, a variety of teaching strategies must be employed, by themselves and/or in combination, if most, if the majority of students are to benefit from teachers' classroom practices. This argument is supported by Kline (1995) who stated: "nothing works every time, everywhere, for everyone. No single strategy, approach or technique works with all students" (p. 22). Kline's focus was on improving teaching in general and he proposed several useful but general teaching strategies. In this review, however, I focused specifically on the teaching and learning of mathematics and the rest of the articles reviewed focused on twelve teaching strategies recommended by D'Ambrosio, Johnson, and Hobbs (1995).

D'Ambrosio, Johnson, and Hobbs (1995) recommended twelve teaching strategies and argued that they promote mathematics achievement. These strategies are:

- *Encourage exploration and investigations:* teachers are encouraged to involve students in activities which will help them to "construct mathematics knowledge" as well as "explore and investigate mathematics ideas" (p. 125).
- *Use students' prior knowledge:* students bring to class different knowledge and experiences of the world which affect the way they view and solve problems. An effective teaching strategy is to "build instructions" that make effective use of these prior knowledge (p. 126).
- *Use manipulatives:* the proper use of manipulatives is critical to the understanding of new mathematical ideas. When appropriately used, manipulatives "greatly enhances students' visualization of mathematical ideas" and three stages of such use are recommended: "(1) the used of manipulative alone, followed by (2) the use of the manipulatives side by side with symbolic paper-and-pencil representation, and then (3) the use of the symbolic representation alone" (p. 126). The second stage is critical and adequate time must be spent during this stage if students are to make a successful transition from the concrete to more abstract forms of representations.
- *Use real-world problem-solving activities*: mathematics is a "lived" subject and relates to everyday living. Hence, students encounter mathematics on a daily basis albeit in different forms and in different places. Therefore, their interest in mathematics may be different. A useful teaching strategy is for "teachers to link mathematics and the real world through a wide range of problem-solving activities" (p. 127).
- *Integrate mathematics with other content areas*: this strategy helps students to "apply previous acquired knowledge to new situations" thus making mathematics more meaningful and relevant (p. 128).
- *Use culturally relevant materials:* this strategy will help to motivate students if the mathematics is related to students' different cultures and interests and if appropriately

used, teachers can "use culturally relevant materials as a spring-board for mathematics instructions" (p. 129).

- *Use technology:* technology is a very important and highly recommended approach to teaching mathematics because of the many benefits it is believed to bring to the teaching and learning process. First, because of capabilities such as performing quick and complex calculations, "spreadsheets, graphing utilities, and structured mathematical environments", "technology can be used as a toll for problem solving" (p. 130). Second, technology allows students and teachers to use powerful software such as "Geometer's Sketchpad, and Algebra Expresser" to "explore mathematical ideas" and LOGO for "constructing mathematical ideas" (p. 130).
- *Use oral and written expression:* the process of explaining their thinking orally and/or in writing help students to "organise their thought" and "solution strategies" and it assists them in building "a rational for justifying" their strategies (p. 131).
- *Encourage collaborative problem solving:* working collaboratively holds many benefits for students. They get involved in: "sharing and negotiating meanings," "verbalizing their understanding," "trying to understand one another's strategies," "providing constructive criticism" and "being actively involved in learning" (p. 132).
- *Use errors to enhance learning:* to simply say an answer is correct on incorrect is insufficient if students are to develop an understanding of mathematics. The thinking behind students' errors must be explored if misconceptions are to be "ironed" out and to enable students to grow mathematically. Hence, "teachers should question the process used to obtain solutions" (p. 133) thus affording students the opportunity to refine and reorganise their thinking.
- *Offer an enriched curriculum and challenging activities:* all "normal" students' mathematics ability and critical thinking skills can be improved by exposing them to challenging mathematics experiences. These experiences must go beyond routine and watered-down procedural tasks to experiencing "mathematics as an inquiry-based discipline in which they ask many questions and allow their curiosity and creativity to guide their exploration and investigation of mathematical concepts" (p. 133).
- *Use a variety of problem-solving experiences:* students must be exposed to a wide variety of problems to include problems: that can be solved in different ways, with

more than one correct answer, and that may involve decision making and allow for different interpretations (p. 135).

Choike (2000) supports several of these strategies. Choike supports the use of *explorations and investigations* in the teaching of mathematics when he stated: “Involve students in guided explorations; use learning-by-discovery teaching strategies” (p. 559). Choike spoke from a position of expertise because he was the “chair of the Equity 2000 National Mathematics Technical Assistance Committee and as an in-service presenter at Equity 2000 professional development institutes for mathematics teachers” (p. 556). He also collaborated with teachers at various levels to “create and demonstrate” mathematics lessons (p. 556). Choike’s support for other strategies, stated in the twelve above, continues.

In support of using *culturally relevant materials*, Choike (2000) stated that teachers should “mould lessons, whenever possible, around the interests of individual students” (p. 560). Choike like D’Ambrosio, Johnson, & Hobbs (1995) is concerned with motivating students through materials which appeal to them. In support for the use of *oral and written expressions*, he called on teachers to “emphasize multiple representations – words, tables of data, graphs, and symbols” (p. 557). He claimed that the use of multiple representations is an “effective strategy for reaching out to students with different learning styles” (p. 557). And in support of using *errors to enhance learning*, Choike encouraged teachers to “learn to recognize correct thinking in students even when it may be incomplete or lacking in closure.” (p. 559). He added that to do so teachers must be good listeners and must be alert to their students’ ways of thinking (Choike, 2000).

While Choike (2000) supports several of the strategies recommended by D’Ambrosio, Johnson, & Hobbs (1995), several other studies support the use of *technology* in the mathematics classroom. Resic and Besic (2013) support the use of computer technology in the teaching of mathematics. In that study, samples of sixth, seventh, and eighth graders were surveyed with students generally showing a positive attitude towards the use of computers in the teaching and learning process. Resic and Besic stated, “employing computers stimulates the most important aspect in teaching mathematics, and that is understanding the subject matter” (p. 110) because there is less concentration on memorizing formulas, and the fear of making calculation errors. The study noted, however, that using computers in the teaching of mathematics can become problematic when issues, such as an over-reliance on the computer, get in the way of students' attempts to memorize important facts or to perform simple mental calculations.

Another recommended use of technology in the mathematics classroom is in the use of interactive whiteboards. Resic and Cukle (2013) concluded that "interactive (smart) whiteboards are an ideal solution for those who want to increase the quality of teaching, to encourage and motivate the students and help to achieve the desired results" (p. 127). These goals can be achieved through the practical and realistic ways in which problems can be represented and solved using available software (Resic and Cukle, 2013). These conclusions were drawn from relevant surveys of teachers and secondary students in Bosnia and Herzegovina.

In the case of *collaborative/cooperative* learning, support came from Sutton (1992) who experienced first-hand how cooperative classroom activities improved her secondary students' achievements in mathematics. Sutton proposed five basic but important elements of cooperative classroom activities.They are: (a) "positive interdependence", in that "students within groups must truly be dependent on one another"; (b) "face-to-face interaction" (c) "individual accountability" where "all students within a group are responsible for learning the material"; (d) "the appropriate use of interpersonal skills in the group; these skills must be taught" and (e) "students must be given time for analysing how well their groups are functioning" (pp. 63-64). Sutton also supported using multiple strategies as critical to learning mathematics in stating "no teacher should rely only on it [cooperative learning]; students and teachers need variety" (p. 66).

The above strategies represent what research has put forward as some of the most significant in the teaching of mathematics. However, it would be remiss to end this section without noting the influence of textbooks on the strategies used in the teaching of mathematics given the heavy reliance on textbooks in Dominican secondary schools. Fan and Kaeley (1998) investigated the influence of textbooks in the secondary mathematics classroom and found that the textbooks used determined, to a significant extent, the strategies employed by teachers. The study found that teachers tended to use the strategies emphasized in the textbooks regardless of the teachers' qualifications and/or years of experience. This finding is significant because the study covered a wide cross-section of well-qualified and experienced teachers in eleven states in the United States who worked in schools, mostly secondary, in "semi-rural, rural, town, suburb, and inner city areas" (p. 9). Therefore, it must be concluded that care must be taken in selecting appropriate mathematics textbooks as a way of assisting teachers to employ effective teaching and learning strategies in the mathematics classroom.

Beliefs about the Teaching of Mathematics

In the foregone section, a number of recommended strategies for the effective teaching of mathematics were presented. Strategies, from above and otherwise, that a teacher chooses to employ in his/her practice are influenced, to a large extent, by his/her beliefs about the teaching and learning of mathematics. To use a common explanation, belief defines a person's idea or principle position which she or he judge to be true (The New International Webster's Vest Pocket Dictionary, 2001). Applying this explanation to mathematics teaching, a teacher's belief refers to the ideas and practices that she or he thinks is best suited to bring about mathematical understanding in students. Following are some reviews of literature regarding the impact of teachers' beliefs about how mathematics should be taught and learned.

Garofalo (1989) argued that "beliefs are important not only because they influence how one thinks about, approaches, and follows through on mathematical tasks but also because they influence how one studies mathematics and how and when one attends to mathematics instruction" (p. 502). Beliefs portrayed by teachers and text, according to Garofalo, influence students' mathematics beliefs and their ways of approaching the learning of mathematics. According to Garoflo, following are four beliefs which both teachers and students usually hold:

- "Almost all mathematics problems can be solved by the direct application of the facts, rules, formulas, and procedures shown by the teacher or given in the text book. That is, mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures" (pp. 502-503).
- "Mathematics textbook exercises can be solved only by the methods presented in the textbook; moreover, such exercises must be solved by the methods presented in the section of the textbook in which they appear" (p. 503).
- "Only the mathematics to be tested is important and worth knowing. For example, formulas are important, but their derivations are not" (p. 503).

- "Mathematics is created only by very prodigious and creative people; other people just try to learn what is handed down" (p. 503).

Garofalo refers to these as "unhealthy beliefs" that "suggest and imply study habits, test taking strategies, and classroom behaviours" (p. 504) as a means of coping with mathematical challenges.

Classroom behaviours and practices are also greatly influenced by teachers' worldviews about teaching and learning; namely, behaviourism and constructivism. Gales and Yan (2001) presents findings, both positive and negative, on students' mathematics achievement as it relates to teachers purporting these two worldviews. The study "investigated the instructional practices" (p. 5) of 527 eighth grade teachers from the United States, drawing from data of the *Third International Mathematics and Science Study* (TIMSS). Gales and Yan found that teachers holding different worldviews engaged in different instructional practices. The sequence "(a) gaining attention, (b) informing the learner of the objective, (c) stimulate recall, (d) present stimulus material, (e) provide learning guidance, (f) elicit the performance, (g) provide feedback, (h) assess performance, and (i) enhance retention and transfer" (p. 12) was employed by most behaviourist while most constructivist: "created educational environments that permit students to assume the responsibility for their learning, builds on the student's existing knowledge base, extends the individual's repertoire of cognitive and metacognitive strategies, and corrects specific learning problems" (p. 13).

These practices, as related to both worldviews, have both advantages and disadvantages. Gales and Yan (2001) reports a "strong negative relationship between teachers who coached the entire class to give the one correct answer and students' achievement in mathematics", however, the authors also reported that "the behaviourist teacher-directed instructional practice of having students give the reasoning behind their answers and discussing several answers before determining the correct answer had a positive effect on student learning" (p. 16).

In respect of constructivists, Gales and Yan (2001) reported that "the data displayed a statistically significant negative relationship between constructivist teachers' beliefs that mathematics is a practical, structured, and a formal guide for addressing real world situations and students' achievement" (p. 16) but revealed that "students, who work on projects where there is no immediate correct answer and find real world uses for the content, have higher achievement levels on TIMSS" (p. 17).

Chung (2009) investigated teachers' perceptions of mathematics education in Korean elementary schools. According to Chung, Korea is in the top percentile in mathematics performance for schools around the world measured by TIMSS (2003), Programme for International Student Assessment (2003), and Organization for Economic Cooperation and Development (2006). Chung surveyed 141 elementary teachers using a questionnaire geared towards soliciting teachers' beliefs about the teaching and learning of mathematics. Reported are the following beliefs. "Real life application is the most important in mathematics education" and "process is very important in teaching mathematics" (p. 243). Teachers also indicated that the use of manipulatives in explaining concepts is important but did not think memorizing an "algorithm to solve mathematics problems" (p. 244) was important in teaching and learning mathematics. Listed in order of importance, "understanding concepts", "understanding principles", and "understanding process" (p. 250), took the top three positions in Korean teachers' belief systems. Chung concluded that "Korean elementary classroom teachers' educational pedagogy is based on Constructivism" (p. 252). Hence, although this study was conducted in an elementary setting, its findings are pertinent to mathematics teaching and learning at the secondary level. The following reviewed article strengthens this claim.

Canto-Herrera & Salazar-Carballo (2010) surveyed 71 secondary teachers of mathematics in Yucatan to gather information on teachers' belief of mathematics teaching and learning. The study reported that mathematics teachers "were more behaviourists in management and more constructivists in teaching" (n. p). The study found a "significant positive correlation between teaching styles and student achievement" (n. p). That is, from the articles reviewed to date, teachers holding a constructivist view of how mathematics should be taught and those who take a constructivist approach to teaching mathematics, appear to be having the most profound, positive effect on students' performance. The next article reports on teachers' belief on students' mathematics ability.

Bossé, Adu-Gyamfi, and Cheetham (2011) investigated student success in translating between different representations in mathematics. Fifteen algebra 2 and 15 pre-calculus teachers from the North Carolina district participated in the study (Bossé, Adu-Gyamfi, &

Cheetham, 2011). Bossé, Adu-Gyamfi, and Cheetham found that teachers' expectations that students would "have difficulty or be unable to do some translations" were "transmitted to students" (p. 14) and thus, affected students' attitudes in the way they approached some of the translations. The study also concluded that "teacher expectations of student abilities" (p. 14) affected teachers' classroom practices in that these expectation caused teachers to "voluntarily limit instructional practices regarding some of the translations they anticipate as most difficult or of lesser importance" (p. 15). Hence, both teachers' beliefs about mathematics and their beliefs about students' mathematics ability can affect students' performance in mathematics.

Summary

From interacting with the work of scholars in the field of education in general and mathematics education in particular, several salient findings were brought to the fore. First, several research studies show that teachers advanced content knowledge, or the lack of it, has an effect on students' performance. However, some studies on the effects of teachers' content knowledge are inconclusive, while other studies identify teachers' pedagogical content knowledge as the decisive factor. Second, there is overwhelming evidence to show that teachers' beliefs, mathematics related and ability related, affect teachers' and students' classroom actions and hence, students' performance in mathematics. Third and final, a number of teaching strategies are recommended by several scholars and teachers are encouraged to use multiple strategies in their mathematics classroom environment. The findings within these reviews were used to help frame the present study and form the basis upon which the study's empirical findings are discussed.

Chapter 3: Research Design and Methods

This chapter outlines the research design and methods employed to explore teachers' explanations of any relationship between students' performance in CXC mathematics examinations and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. It describes the explanatory sequential mixed method design used in this study. The issues of integration and priority in this design are discussed and reasons for choosing this sequential design are given and clarified. A graphical representation of the study design is also given. The chapter also addresses the issue of data collection. It explains both phases of the study detailing participants' characteristics, the instruments used, procedures employed, and analyses carried out. Also discussed are the ethical issues that were considered during this study. Issues of informed consent and adhering to guidelines for human research are both addressed. The chapter ends with a summary of its content.

Study Design

Creswell's explanatory sequential mixed methods (Creswell, 2013) design was used in this study. An initial set of data was collected and analysed in a quantitative phase and the results of this analysis was used to inform a second research phase – the qualitative phase. In the quantitative phase, data were collected through a paper based survey on teachers': mathematical knowledge measured by the number of post-secondary mathematics content and pedagogical content courses taken; frequency of use of recommended teaching strategies taken as reported by teachers; and teachers' beliefs about the teaching and learning of mathematics as reported by participating teachers. The qualitative phase was used to gain further insights into the quantitative data set, hence, integrating the two sets of data.

Integration of Phases

Integration, in this design, refers to the stages in the research process where mixing of the quantitative and qualitative phases occurs (Creswell et al., 2003). In this study, the quantitative and qualitative phases were integrated at three stages of the research process. First, mixing took place at the design stage when I crafted the main research question: *In what ways will Dominican secondary mathematics teachers explain any relationship between* *students' CXC mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?* The research question calls for teachers' explanations – qualitative – of existing factors – quantitative. Second, mixing took place while developing the interview questions for the qualitative data collection (focus group discussion). Three discussion questions were developed based on the results of the analyses in the first phase. One question focused on the result of the analysis of teachers' content and pedagogical content knowledge, a second question focused on the result of the analysis of the frequency of use of 12 recommended teaching strategies, and a third question focused on the result of the analysis of teachers' reported beliefs about the teaching of mathematics. And third, mixing occurred in the discussions of the results from the quantitative and qualitative phases. These discussions were integral in the interpretation of the outcomes of the entire study. The qualitative phase was given greater priority in interpreting the outcomes of the study.

Priority Given to Both Phases

Priority refers to the weighting given to each, quantitative and qualitative, phase of a mix method design and is particularly important during the data collection and analysis processes in the study (Creswell et al. 2003). According to Creswell (2013), priority is normally given to the quantitative phase in the sequential explanatory design, because the quantitative data collection comes first in the sequence and frequently embodies the main part of the mixed-methods data collection process. However, Creswell asserts that priority may be shifted to the qualitative phase, or both, depending on the goals of the study, the scope of the research question(s), and the intention of each phase.

In this study, *A Study of Dominican Secondary Mathematics Teachers' Explanations of Factors Affecting Their Instructional Practices*, I decided to give greater priority to the qualitative phases because the main research question asks for teachers' explanations of any relationship between students' CXC mathematic performance and teachers' mathematical knowledge, use of recommended teching strategies, and beliefs about the teaching of mathematics. Hence, the collection and analysis of quantitative data–mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics–served the primary purpose of informing the collection of qualitative data during the focus group discussion.

Assigning greater priority to the qualitative phase is further justified in terms of time and opportunities for clarification. During the data collection process, contact was made only once with participants during each phase of the study. During the quantitative phase, participants completed a questionnaire, and participants in the qualitative phase met once for a focus group discussion. In the quantitative phase, participants took, on average, 15 minutes to complete the questionnaire. In the qualitative phase, participants were engaged in discussion for approximately 120 minutes. The significant additional time spent in the group discussion – qualitative data collection phase – allowed participants to refine their thinking as they draw on the contributions/discussions of their peers. These discussions afforded them the opportunity to clarify survey questions which may have been previously misunderstood, thus, allowing these group participants to offer more meaningful contributions. Survey participants did not have such opportunities for clarification.

A further justification in assigning greater priority to the qualitative phase is in the statistical techniques employed in the analysis of each phase. Quantitative analysis made use only of frequency tables while qualitative analysis made use of transcribing teachers' direct quotes and thematic analysis. Thematic analysis was also performed on two levels: within and across domains–mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematical–of the research question.

Justification for Choice of Methods

The explanatory sequential mixed methods design allowed me to use a pragmatic approach to solicit an explanation from teachers in regards to possible effects that their mathematical knowledge, beliefs about the teaching of mathematics, and teaching strategies had on Dominican students' mathematics performance. I was able to utilize a "practical and outcome-orientated method of inquiry" (Johnson & Onwuegbuzie, 2004, p. 17) based on several actions which were geared towards the elimination of doubts. These actions primarily surrounded the use of a survey which later informed a focus group discussion. That is, the focus group discussion helped me to find plausible explanations to questions that arose after the analysis of the survey data. The prospect of eliminating doubt was particularly appealing and the above quote, along with similar views expressed by experts in mixed methods research such as Ragin and Becker (1992) and Creswell (2009) captured the essence of my aim in undertaking this research study. Hashemi and Babaii (2013) put it perfectly:

> In fact, experts in research methodology increasingly believe that qualitative and quantitative methods can coexist in a dialectical relationship and that findings from the two strands, being convergent or divergent, enhance the understanding of the phenomenon under study. In reverse, absent one or the other, many questions would remain only partially answered or even wholly unanswered. (p. 829).

The value of this research is too important to me and the future of mathematics education in Dominica to settle for any methodology that is likely to leave me with doubts and more questions than answers. I am not so naïve to believe that this single study will answer all questions about Dominica's secondary mathematics performances, but it is incumbent upon me to take steps to gain as much insight as is possible within this single study. For me, selecting the Explanatory Sequential Mixed Methods Design is a step in the right direction.

Another major feature of the Explanatory Sequential Mixed Methods design, which is critical to my study, is its dual characteristics of providing generalizability and in-depth understanding. Bazeley (2004), Ragin (1987), Hashemi and Babaii (2013), Simpson (2011), and Creswell (2009; 2013) all commented on the dual nature of this mixed methods approach in research. In Bazeley's own words: "the dual purposes of generalisation and in-depth understanding - to gain an overview of social regularities from a larger sample while understanding the other through detailed study of a smaller sample" (2006, p. 145) makes my argument for selecting this mixed method as my preferred methodology. Because I was in Alberta conducting a study in Dominica which is thousands of miles away, not only was I limited by distance but, more important, I was limited by financial and time resources. Yet, this study had to be conducted so that its findings could be generalized to the secondary schools' teacher population and, at the same time, an in-depth understanding of the impact teacher-factors have on students' mathematics performance could be gained. Under these circumstances, my best option is to work towards what Bazeley articulated above.

A final argument in my choice of methodology is personal in nature. I am a mathematics-oriented individual. Hence mathematical procedures come more naturally to me. Explanatory Sequential Mixed Methods design is strong on mathematical methods and hence well-suited for me, having a strong mathematical background. Both Creswell (2009; 2013) and Simpson (2011) support this point. Simpson states: "the explanatory sequential approach is a good choice for researchers who have a mainly quantitative background" (p.

28). Needing to choose a methodology that complements my background and, at the same time, provides the generalizability and in-depth understanding I needed in this research, the Explanatory Sequential Mixed Methods Design became my methodology of choice.

Visual Model

Figure 3.1 is a visual model of the steps I used in this research study. The model illustrates each phase of the research, the procedure used, and the resulting product.

Phase	Procedure	Product
Quantitative Data Collection	Paper base survey (n = 47)	Numeric data
Quantitative Data Analysis	SPSS software (V. 22)	Frequency tables Bar-charts, Scatterplots
Connecting Qualitative and Qualitative Phases	Using analyses of quantitative data to develop questions for the focus group discussion	Discussion protocol
Qualitative Data Collection	Group discussion (n = 6) Audiotaping	Audiotaped Data
Qualitative Data Analysis	Listening and transcribing Identifying themes Selecting quotes	Themes within domains Themes across domains Quotes
Integration of Quantitative and Qualitative Results	Explaining the quantitative results using the qualitative results	Discussions Implications limitations

Figure 3.1: Visual model of design used in this study

Data Collection and Analysis: Quantitative Phase

This section presents the instrument used, procedures employed, and participants who provided the quantitative data for this study. The instrument was a paper based questionnaire designed to collect different types of quantitative data on teachers. Teachers were asked to provide answers to prompts by selecting relevant options from tables. Described also are the data collection procedure and the analysis methods and procedures. Data collection was done at participants' schools with the assistance of their principals. Data analysis was done using SPSS quantitative analysis software. A detail description of the group of participants is also provided.

Instrument.

Every fourth and fifth form mathematics teacher, in Dominica, was given a paper based questionnaire to complete. This questionnaire (see Appendix 2), was a modification of one developed and used by Dr Elaine Simmt and her colleagues in a similar but broader study conducted in Tanzania (Simmt et al., 2013). I had their permission to modify and use it. I chose to use a paper-based medium because it was easier for control and I felt that using it over a computer base survey would allow for an improved response rate. This decision was based on two factors:

- I am aware that the use of schools' computer laboratory can be problematic, in that, usage of the limited computer space available at many schools may be restricted and scheduled. Also, not all teachers have access to computers in their staffroom and I am not certain how many teachers have access to the internet at home. The paper based questionnaire gave all targeted participants access to the survey.
- I believed that teachers having to give back the questionnaire, versus submitting it online, encouraged them to complete it. The response rate was excellent with the only drawback in using the paper base instrument being the amount of time I needed to transfer the data into the computer for analysis. Several hours were taken as the instrument measured several factors about teacher participants.

The survey instrument (questionnaire) was designed to measure participating teachers' demographics, schools' CXC mathematics pass rates, teachers mathematics content (as determined by the number of post-secondary mathematics courses completed) and pedagogical content knowledge (as determined by the number of mathematics pedagogy courses complete), frequency of use of recommended teaching strategies, teachers' beliefs about the teaching of mathematics, and teachers' support systems. Information on teachers' demographics was used to describe the participants and information about tearchers' support system helped to provide the context in which participants teach. This context, while not an integral part of the study, will help readers better understand the study and, hence, better position the study in relation to similar studies in the field. All other information collected through the questionnaire formed an integral part of the study.

The instrument was divided into five labelled sections: section A–Demographics and other, section B–Teacher Education Qualification, section C–Mathematics teaching and learning, section D–Mathematics beliefs, and section E–Support and Resources. Following are brief descriptions of each section of the instrument, however, the full instrument is given as Appendix 2.

Section A solicited information on participants gender, age, and school's performances in CXC mathematics examinations for the years 2012, 2013, and 2014. Participants' ages were recorded in ranges: under 20, 20 – 29, 30 – 39, 40 – 49, and 50 and above.

Section B solicited information on whether or not participants were trained or in training; whether training took place at a teacher training institution in Dominica, out of Dominica, or at a university; years of teaching experience in mathematics and in other subject areas; highest academic qualification in mathematics and in other areas; the number of post-secondary mathematics content courses taken; and the number of pedagogical content courses taken. Years of teaching experience were reported in ranges (5 or less, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 – 30, 30 or more); qualifications listed in ascending order were CXC general proficiency, A-level, Associate degree, Bachelor degree, Master degree, and above a Master degree; and content courses taken were divided into courses taken at Dominica state college and like institutions, university undergraduate level, and university graduate level. Participants were required to write the number of pedagogical content courses taken and indicate any other training they had received in the teaching of mathematics.

Section C focused on practices employed in the teaching of mathematics. Information on whether a participant taught in a single sex or co-education school and the form levels participants taught, were solicited. Of great significance to the study was the solicitation of information regarding how frequently teachers used 12 recommended teaching strategies (D'Ambrosio, Johnson, and Hobbs, 1995). Strategies covered were participants' use of explorations and investigations, use of students' prior knowledge, use of manipulatives and/or visual aids, use of real world problem solving activities, teacher integration of mathematics with other subject areas, use of technology, use of both written and oral forms of expressions, encourage collaboration among students, use students' errors to enhance learning, offer an enriched curriculum and challenging activities to all students, use of both convergent and divergent problems, and use context and materials that a culturally relevant to students. The frequencies of use for these 12 strategies were measured on a Likert type scale. The scale was a 6-point scale ranging from zero to five with a score of zero indicating that a strategy was never used while a score of five indicated that a strategy was very frequently used. Participants were also asked to indicate other strategies that they used in their classroom that were not listed on the questionnaire.

Section D focused on participants' beliefs about the teaching and learning of mathematics and solicited information through a 5-point Likert type scale. Participants' views on fourteen belief statements were measured using opinion points: strongly agree, agree, neutral, disagree, and strongly disagree. The instrument solicited participants view on the following 14 belief statements (Garofalo, 1989; Gales & Yan, 2001; Chung, 2009):

- Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures.
- Only the mathematics to be tested is important and worth knowing. For example, formulas are important, but their derivations are not.
- It is important to adhere to the methods and strategies prescribed in textbooks.
- The sequence: (a) gaining attention, (b) informing the learner of the objective, (c) stimulate recall, (d) present stimulus material, (e) provide learning guidance, (f) elicit the performance, (g) provide feedback, (h) assess performance, and (i) enhance retention and transfer; is the best approach to teaching mathematics.
- Creating an educational environment that permit students to assume responsibility for their learning, building on students' existing knowledge base, extending students' repertoire of cognitive and metacognitive strategies, and correcting specific learning problems; is the best approach to teaching mathematics.

- Real life application is the most important in teaching and learning mathematics.
- Process is the most important in teaching and learning mathematics.
- To teach mathematics, we need to explain concepts using concrete materials.
- When introducing a new concept, we always need to use concrete objects.
- I need to help children develop abstract knowledge from concrete examples by illustrating the concept using concrete models.
- In mathematics teaching, conceptual understanding is very important.
- In mathematics teaching, procedural knowledge is very important.
- I feel my students learn mathematics well through my instructional methods.
- All [normal] students, both male and female, can learn mathematics.

Participants were also asked to indicate other beliefs about the teaching and learning of mathematics which they hold strongly.

Finally, section E solicited information on the availability of teaching support and resources to mathematics teachers. A 5-point Likert type scale using opinion points: strongly agree, agree, neutral, disagree, and strongly disagree was uses to get teachers opinion on the following 12 statements (Simmt et al., 2013).

- Mathematics in-service courses or workshops have been facilitated by my school in the last year
- Mathematics in-service courses or workshops have been facilitated by Ministry of Education in the last year.
- I have attended at least one available mathematics in-service courses or workshops in the last year.
- I know where to go when I need assistance with my mathematics teaching.
- The school has got resources available to support the teaching and learning of mathematics.
- I have access to multiple texts or reference books for mathematics.
- I am aware of resources outside my school that can support my teaching and learning of mathematics
- I do use resources outside the school that support my teaching and learning of mathematics.

- I do partner with mathematics teachers from within my schools when planning for my teaching of mathematics.
- I do partner with mathematics teachers from other schools when planning for my teaching of mathematics.
- I have access to mathematics or mathematics education experts if assistance is needed in planning and/or teaching areas in mathematics.
- I have access to computer technology that can be used in the teaching of mathematics.

A colleague at the Ministry of Education in Dominica, with the collaboration of school principals, assisted me in administering this survey instrument.

Procedure.

Copies of the survey instrument were packaged and given to principals of the fifteen secondary schools with accompanying guidelines for conducting the survey. Packaging and distribution of the instrument was done with the assistance of the Senior Education Officer, with responsibility for secondary schools in the Ministry of Education in Dominica. Her knowledge of and ease of access to school principals made it easier to get principals' cooperation. Such knowledge also ensured that an adequate number of forms were sent to all schools, thus, saving me time and money.

The survey process started with an information letter and consent form sent to participants, through their principals, and ended with the collection of the completed forms. Principals were asked to read the letter to their staff and display it in a conspicuous place at their school. The information letter discussed several key aspects of the study: participants, purpose, procedure, benefits, risks, and confidentiality and anonymity issues (see Appendix 3). Attached to the information letter was also a consent form for teachers' perusal. This consent form, along with the information letter, aimed to assure targeted teachers that their participation in the study was completely voluntary. More importantly, the information letter and consent form prepared them for the actual survey, thus, helping to lessen the anxiety activities like a survey may bring to individuals.

Approximately two weeks after the information letter was sent to schools, the survey forms followed. These forms, one for each participating teacher, were given to schools' principals for distribution to the relevant teachers. Participating teachers completed their form by filling in required sections and/or selecting appropriate answers from a list. The completed forms were returned to the principal, who collected and secured them. These completed forms were given to the Senior Education Officer, in a sealed envelop, who passed them on to me. The entire process took approximately ten weeks and several telephone calls to principals, who had to constantly remind teachers to complete and return their form. The completed forms were handed to me in early December, 2014.

Analyses.

IBM SPSS statistics software (version 22) was used to analyse the quantitative data keeping in mind that the principal purpose for this analysis was to inform data collection in the qualitative phase. Both descriptive statistics and frequencies were determined and used in the analysis of the data.

In the knowledge domain of the research question, frequency tables, bar-charts, and scatter plots were constructed using teachers' (a) content knowledge, (b) pedagogical content knowledge, and (c) combined content and pedagogical content knowledge–mathematical knowledge. Three scatter plots were constructed using school's 2014 CXC mathematics performance, as reported by survey participants, as the dependant variable and (a) content knowledge, (b) pedagogical content knowledge, and (c) mathematical knowledge as the independent variables (see Appendix 5 for the Booklet used in the focus group discussion). These scatter plots and bar-charts, however, were used only for the purpose of the group discussion and do not form part of the analysed results presented in chapter 4; only the frequency tables are presented in chapter 4. The bar-charts and scatter plots served a primary purpose of having focus group participants describe any relationship that they might see between students' 2014 CXC mathematics performance and teachers' mathematical knowledge and would only present redundant information if they were taken further. Group participants were asked to eye-ball the scatter plots to identify any apparent relationships.

In the strategy domain of the research question, frequency tables and histograms with accompany curves were constructed for each strategy and the mode, mean, and standard deviation for each strategy were determined. These were presented to participants during the group discussion. Again, the intent was to give group participants several perspectives on the data, thus, affording them multiple opportunities to make sense of the data which would in turn improve the meaningfulness of their contributions. Like in the case of the mathematical knowledge domain above, only the frequency tables are presented in the analysis in chapter 4.

In the domain regarding teachers' beliefs about the teaching of mathematics, a single table showing the analysed results of the survey was used during the group discussion. This table, however, was divided into four smaller tables to present teachers' beliefs as categories in chapter 4. A single table was used in the group discussion in an effort not to influence teachers' contributions since the names given to each category (eg. unhealthy beliefs) could have had significant influence on participants' thinking. In chapter 4, narratives were used to explain the relevant findings for each section. All of the above were made possible by the teachers who completed the survey.

Participants.

Participants were recruited from 15 (all) secondary schools in Dominica. All fourth and fifth forms (11th and 12th grade) mathematics teachers in Dominica were targeted. These people were targeted because the group contains fewer than 50 teachers, and these people teach the bulk of the CXC mathematics syllabus in Dominica. Some mathematics teachers were excluded from the study. The exclusion criteria were lower secondary teachers and primary school teachers. Lower secondary and primary mathematics teachers teach very little, if any, of the mathematics tested in the CXC examination. These teachers, however, lay the foundation for the mathematics to be tested by CXC. Excluding them from the study, therefore, was not because they did not have valuable information to share, but because of the additional cost and time that their inclusion would incur. Further, lower secondary and primary teachers' practices were beyond the scope of this study. The survey was conducted between September and November of 2014.

Table 3.1 shows that 47 teachers responded to the survey. At least 27 (57%) of the respondents were female and at least 17 (36%) were male. Eighteen (38%) of participants were under the age of 30; 23 (49%) participants were between the ages of 30 and 50, and four (9%) participants were 50 years or above.

Age Range	Male	Female	Not Stated
Under 20	1	-	-
20 – 29	7	10	-
30 – 39	5	8	2
40 – 49	3	5	-
50 and above	1	3	-
Not Stated	-	1	1
Total	**17**	**27**	**3**

Table 3.1: Distribution of teachers' gender and age

Table 3.2 indicates that 23 (49%) participants were trained teachers–completed a formal program of study related to teaching and education issues and five (11%) participants were in training–enrolled in a formal program of study related to teaching and education issues. That is, only 28 (60%) upper secondary mathematics teachers who responded to the survey had received some degree of formal training in respect to teaching and/or education issues. At least 17 (36%) participants had not received any formal teacher training.

Training	Number of Teachers
Untrained	17
In training	5
Trained	23
Not stated	2

***Table 3.2*: Distribution of training among teachers

Table 3.3 shows that the majority, 29 (62%) participants had 10 or less years of experience teaching mathematics. Only four (9%) participants had over 25 years of experience teaching mathematics, 14 (30%) participants reported between 11 and 25 years of experience teaching mathematics.

Years of Experience Teaching Mathematics	Number of Teachers
1 – 5	10
6 – 10	19
11 – 15	7
16 – 20	4
21 – 25	3
26 – 30	3
> 30	1

Table 3.3: Years of experience teaching mathematics

Table 3.4 shows that more than half of the respondents, 24 (51%), were teaching mathematics at the upper secondary level with less than a first degree in the area of mathematics. Of these 24 participants, nine (37.5%) participants were teaching with CXC mathematics as their highest qualification in mathematics, six (25%) were teaching with A-Level mathematics as their highest qualification in mathematics, and nine (37.5%) had Associate degrees in mathematics. Further, 17 (36%) participants were teaching with a first degree or higher in the area of mathematics and/or mathematics education.

Highest level of Qualification in Mathematics	Number of Teachers
Caribbean Examination Council (CXC)	9
A – Level	6
Associate degree	9
Bachelor degree	16
Master degree	1
Not stated	6

Table 3.4: Distribution of highest level of Math qualifications

Data Collection and Analysis: Qualitative Phase

The participants, instruments, methods and procedures, and analysis presented in this section are different from those presented in the quantitative phase above. The group of six participants described in this section came from the larger group of fourth and fifth forms teachers who participated in the quantitative phase and were among the most experienced in teaching mathematics in Dominica. The foucs group questions used were developed from the quantitative data and included a power point presentation (see Appendix 4) and a document (see Appendix 5) containing analysed quantitative data. Described also is the focus group discussion used to collect data and the methods used to analyse this data. In the data analysis, themes within and across domains were identified and quotes were transcribed.

Participants.

Six teachers participated in the focus group discussion which lasted approximately two hours. This group of teachers were recruited from the bigger body of fourth and fifth forms teachers who participated in the quantitative survey. At the time of the survey, consent forms were given to teachers who were interested in participating in the focus group discussion, and these forms were collected together with the completed survey forms. Over thirty teachers indicated their interest, however, teachers from three of the fifteen secondary schools showed no interest. Twelve teachers were initially invited to join the discussion using two selection criteria: (a) one teacher from each of the twelve schools, that showed interest, was invited. I thought that in having teachers from different schools, with different cultures, would provide for more diverse views and more intellectual conversations; and (b) teachers known to take part in organised mathematics activities were targeted. This was done to increase the chance that all participants would be vocal and share their views and the views of their school. That is, I wanted to reduce the chance that any participant would feel intimidated and refrain from sharing. I was the first president of the National Association of Mathematics Educators (NAME) in Dominica. That position and my work as a numeracy specialist with the Ministry of Education placed me in a position to know teachers who are passionate and vocal about the teaching and learning of mathematics. I used that knowledge to target teachers at the different schools for my focus group discussion. Not all teachers who were targeted responded to the invitation to participate in the focus group.

Of the 12 teachers initially invited; five responded positively. As a precaution and in an effort to ensure that I had at least five participants, I contacted and invited, by telephone, a sixth teacher. These six teachers constituted the focus group of five female and one male coming from five different schools. Three of the schools, from which four of the six teachers came from, were in the capital (Roseau) area, one teacher came from a school located in the next largest city (Portsmouth) area, and one came from a rural school. Five of the six teachers were head of the mathematics department at their school and all six teachers came with significant years of teaching experiences and varying levels of qualifications. All six teachers had over 10 years of experience teaching mathematics with one teacher having over 25 years of experience teaching mathematics. Three of the teachers had B.Ed. degrees in secondary mathematics education, one had a B.Sc. in mathematics, one had a B.Ed. in secondary science education, and one had A-level mathematics as his/her highest qualification in mathematics. These six participants were exposed to analyses of the quantitative data and a power point was used to lead them into the discussion.

Instrument.

A booklet (see Appendix 5) containing the analysis of the quantitative data was prepared by me and given to the six teacher participants. The booklet focused on the three domains of the main research question–mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematics. Page 1 was a cover page showing the name of the project, the reason for undertaking the project, and my affiliated school. Page 2 of the booklet contained the main research question and the three sub-questions of the study. These were provided to give participants a feel of the information being solicited from the group discussion. Pages 3, 4, and 5 provided analyses of surveyed participants' content knowledge, pedagogical content knowledge, and combined content and pedagogical content knowledge respectively. On each of these three pages a frequency table, a bar-chart, and a scatter plot were presented. Pages 6 to 17 contained the analyses of the twelve teaching strategies presented to teachers in the survey. Each of these pages showed the analysis of one strategy and presented a frequency table and a histogram with accompanying curve. Also shown on each page is the mean and standard deviation associated with each strategy. The final page, page 18, presented a single table showing the analysis of surveyed participants' beliefs about the teaching and learning of mathematics. The table listed the fourteen beliefs statements presented in the survey and the distribution of participants answers to these statements.

A power point presentation (see Appendix 4) was used to initiate discussion at three points during the group discussion. This power point presentation was prepared by me and contained five slides. The first slide showed the type of activity (group discussion) teachers would be engaged in, the purpose (preparation of M.Ed. thesis) of the focus group discussion, my name and the school I am affiliated with. The second slide highlighted three important research findings about the relationships between (1) content knowledge and mathematics performance–weak but positive correlation, (2) pedagogical content knowledge and mathematics performance–stronger positive correlation than between content only and performance, and (3) the effect of combined content and pedagogical content knowledge (mathematical knowledge) on mathematics performance –strongest correlation. Slide 2 ended with the question "how would you explain the lack of correlation between Dominican students' CXC performance and their teachers' CK, PCK, and combined CK and PCK?"

The third slide focused on the teaching strategies investigated in the survey. On the slide, three points were highlighted. (1) The strategies investigated in the survey were all highly recommended by a number of researchers in the field and these strategies have been reported to have positive influences on students' mathematics performance. (2) The analysis of these strategies from the survey data shows that Dominican teachers were using these strategies very frequently. (3) Despite the frequent use of these recommended strategies, Dominican secondary students continued to perform poorly in mathematics at the CXC level. The slide ended with the question: “since our teachers have been using all of the recommended teaching strategies with high frequency, how would you explain our dismal CXC mathematics performance over the years?”

The penultimate slide, the fourth slide, dealt with the analysis of teachers’ belief statements about the teaching of mathematics. The slide pointed out that, based on their responses to the beliefs statements, Dominica’s secondary mathematics teachers have a very positive outlook regarding the teaching and learning of the mathematics. This positive outlook, however, is not reflected in Dominican secondary students CXC mathematics performance. Participants were asked: “are these beliefs reflected in the teaching practices of Dominica’s secondary mathematics teachers?”

The final slide, the fifth slide, asked participants to comment on any aspect of the data or study they wish to comment on. The slides were introduced at different points in the focus group discussion and allowed participants to engage in discussions that were directed and focused.

Procedure.

Discussions followed each lead question with teachers given the opportunity to voice their explanations and comments. The focus group discussion was audiotaped. The meeting started at about 2:00 p. m., after secondary schools were out for the day. Hence, participating teachers were not deprived of contact time with their students. We, the six teachers and I, met in a resource room of the Ministry of Education where we were able to sit around a large table and faced each other. With the audio recorder placed on the table, we began our discussion.

First, some ground rules to govern the discussion were communicated to the participants. I asked that all participants’ views be respected as there was no right or wrong answers. I wanted all participants to feel free to share their every thought. Teachers were also asked to allow one person to finish making a contribution before speaking. This, I told them, allowed each person to complete what they had to say and also allowed for clearer recording. Teachers were also asked to disagree with their colleagues, if they felt the need to, as this allowed for more intellectual conversations. They were asked, however, to do so in a respectful manner. With these basic ground rules set, we turned our attention to the booklet containing the analyses of the survey data.

We examined and discussed the analysed data for surveyed participants' content knowledge, pedagogical content knowledge, and the combination of the two. I facilitated that aspect of the discussion by pointing out some salient facts as presented in the tables and charts, on pages 3, 4, and 5, and allowed participants to comment on any aspect of the information they wanted to. At that point we were only concerned with making sense of the analyses and were not trying to account for or interpret the data. Here, we looked at the different numbers and percentages of participants with post-secondary mathematics content courses and mathematics pedagogical content courses, and the relationship between the numbers and students' performances. We took approximately eight to 10 minutes discussing the analyses on pages 3, 4 and 5 before attempting to interpret the data.

We began our interpretation with me introducing the content on the second slide of the power point presentation. The slide was made visible to all participants using an LCD projector and was projected on a whiteboard at the front of the room. I read aloud the information from the slide including the question and the slide remained visible throughout that aspect of the discussion. For the most part, the ground rules were respected. That aspect of the discussion lasted approximately 30 minutes after which we turned our attention to the analysis of the teaching strategies.

Discussions on the analysed results for the frequency of use of recommended teaching strategies and the analysed belief statements followed a similar pattern as the discussion on the analysed content and pedagogical content knowledge. That is, eight to 10 minutes were spent examining and discussing the analysed data in each section followed by 20 to 30 minutes of discussion where participants shared their views on the topics. In the frequency of use of recommended teaching strategy section, each of the 12 strategies was looked at individually with particular attention being paid to their mode, mean, and cumulative frequencies. In the belief section, each belief statement was also looked at individually with particular attention being paid to the percentage of participants who responded positively verses those who responded negatively to these statements. Slides 3 and 4 of the power point presentation were used to focus participants' interpretive discussions on the analysed results on the frequency of use of recommended teaching strategies and the analysed results of the belief statements respectively.

The final 10 to 15 minutes of the focus group discussion allowed participants the opportunity to share their views on other factors they thought were affecting students' performance on CXC mathematics examinations. Discussion during this time was a casual conversation while participants took a snack. The entire focus group discussion, including the final 10 to 15 minutes, was analysed for themes within and across the knowledge, strategy, and belief domains.

Analyses.

Themes were identified after carefully listening to the entire recording several times, then, carefully transcribing relevant sections. This analysis was undertaken in four stages: (1) I listened to the recording of the focus group discussion in its entirety several times to get an overall impression of the content; (2) I listen to and transcribed sections under each question, paying careful attention to participants' contributions to each of the three questions (see Appendix 4). (3) I read the transcriptions and identified themes within each domain; (4) using the themes identified within each domain, I identified themes that were similar across domains (Taylor-Powel & Renner, 2003). These cross domain themes were used to provide a full description of participating teachers' explanation of any relationship between students' performance on CXC mathematics examinations and Dominica's fouth and fifth forms teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics.

Teachers' explanations are supported by transcribed sections of the audiotaped discussion. These transcribed sections were selected based on their direct relevance to identified themes and the emphasis they give to explanations (Taylor-Powel & Renner, 2003). All transcribing was done by me and individuals' contributions were identified using Teacher A, Teacher B, etc. which was done to anonymise the data. Discussions took into consideration transcripted quotes and analysed figures were used to integrate the qualitative data with the quantitative data, with greater emphasis place on the qualitative data. As such, a comprehensive interpretation of the data was presented.

Ethical Considerations

Permission to conduct this study was received from the Research Ethics Board at the University of Alberta. According to the research ethics board "ethics review is focused on protection of the participants and maximizing benefits while minimizing harms" (Uuniversity of Alberta, n. d, p. 1). This is in keeping with University of Alberta policies as well as provincial and federal legislations and regulations (University of Alberta, n. d).

In adherence to these policies, legislations, and regulations; informed consent was gained from all participants involved in the study. The research ethics board guidelines on informed consent (University of Alberta, 2013) demanded that attention be paid to participants' capacity to make their own decision. It also demanded that sufficient information be provided to potential participants to allow for their consent to be an informed one. Of particular importance, participants' consent must be voluntary based on sufficient information and adequate understanding of both the proposed research and its implications (University of Alberta, 2013).

Also, the collection and management of data adhered to the guidelines of the research ethics board of the University of Alberta. Participants' information, provided in the survey if they were interested in participating in the qualititative phase, was anonymized to maintain confidentiality and protect participants. Also, the storage of data, both quantitative and qualitative, was aligned with recommendations from the research ethics board. All data are stored securely in my apartment. Once the study is complete the data will be gathered and stored securely for five years after which all data will be adequately destroyed.

Strengths and Limitations of the Study

My study had several strengths and limitations. Strengths include the mixed methods design, which allowed me to investigate: the prevalence of mathematics content and pedagogical content knowledge among Dominican secondary teachers, the frequency of use of twelve recommended teaching strategies by these teachers, and if these teachers' beliefs were reflected to their teaching practice. At the same time, the study also facilitated a deeper understanding, through teachers' explanations given in a group discussion, of any relationship, or lack of, which existed between students' CXC mathematics performance and the teacher factors under investigation. Other strengths are the use of an instrument developed and used by trained and experienced researchers and conducting a paper base survey which yield a high response rate among tagetted participants.

This study is limited in several ways. First, many individuals from the sample of surveyed teachers know me from working as a numeracy specialist in the Ministry of Education in Dominica, as a vocal member of the mathematics heads of department body, and as the president of the National Association of Mathematics Educators (NAME). Knowing that I would be analysing their answers could have influenced them to respond to the prompts in a manner that would please me which may not have been entirely truthful. I tried minimizing such an occurrence by informing participants that once collected it was impossible to identify their answer sheet.

Second, my bias as an experienced mathematics teacher from Dominica could skew the result of the study. I am cognisant of many of the issues faced by Dominican mathematics teachers and have my own thoughts and opinions on how they should be dealt with. This could have influenced my facilitation of the group discussion; giving rise to explanations I wanted to hear. Attempts were made, however, to minimize my bias by allowing the free flow of discussion among group participants; allowing all views to contend.

Third was participants' reliability. Participants' honesty and candour may be influenced by a desire to look good and from fear of reprimand. For example, a teacher who is aware of good teaching practices but does not use them may feel guilty. Sure feeling of guilt may force that teacher to elevate their responses to reflect what they know should be happening and not what is actually happening. Also, teachers at different stages of their teaching career may react differently to survey prompts. Experienced teachers who are well set in their positions may feel free to express their thoughts and opinions with little to no fear of reprisal. Younger teachers, however, who are not set, may feel pressured to elevate their responses for fear of reprisal. Dominica is a small society and the teaching workforce is a very small fraction of it. Even when told otherwise, teachers may still be of the notion that their responses may be recognised and communicated to their supervisors. Hence, some teachers may feel intimidated and adjust responses based on the belief that they will suffer negative consequences from authority figures if they provide mediocre responses.

Chapter 4: Results and Discussions

Both quantitative and qualitative results, along with relevant discussions, are presented in this chapter. The chapter is sectionalised to present results and discussions by three domains: mathematical knowledge; teaching strategies; and beliefs about the teaching of mathematics. Results and discussion on the knowledge domain is presented first, followed by results and discussion on the teaching strategies domain, and then results and discussion on the beliefs about teaching of mathematics domain. In all sections, however, the quantitative analyses were used primarily to provide the basis for group participants' discussions on the respective section. The qualitative analyses in each section were then used to formulate teachers' explanations in response to the main research question: *In what ways will Dominican secondary mathematics teachers explain any relationship between students' CXC mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?* Further, results and discussion on the support system available to Dominican teachers are presented. The chapter ends with a summary which highlights significant results and discussions.

Mathematical Knowledge

This section presents the results of the content knowledge (as measured by the number of post-secondary mathematics courses completed), pedagogical content knowledge (as measured by the number of mathematics pedagogical content courses taken), and mathematical knowledge (as measured by the combined numbers of content and pedagogical content courses taken) of fourth and fifth forms mathematics teachers in Dominica. It specifically presents the analysis of the relevant quantitative data obtained from the survey, followed by the analysis of the relevant qualitative data obtained from the focus group discussion.

The quantitative analyses reported in this section make use of three frequency tables. The first frequency table presents the analysis of mathematics teachers' content knowledge, the second frequency table presents the analysis of mathematics teachers' pedagogical content knowledge, and the third frequency table presents the analysis of mathematics teachers' mathematical knowledge. The first column of each respective frequency table shows the number of post-secondary content courses, the number of pedagogical content courses, and mathematical knowledge. The other four columns of each respective frequency table shows: frequency–the number of teachers who have taken a particular number of courses; percent–the percentage of teachers falling within a particular range; valid percent–the percentage of teachers falling within a particular range accounting for survey participants who did not respond to that prompt; and cumulative percent–the running total of the valid percent.

The qualitative analysis makes use of themes and quotes from group participants: Each identified theme is supported with participants' direct quotes. These themes and quotes form the basis of the discussion used to integrate the quantitative and qualitative data in respect of teachers' mathematics content knowledge, pedagogical content knowledge, and mathematical knowledge. More specifically, the qualitative data collected through the group discussion, provided the basis for teachers' explanations for any relationship, or lack of, which they observed between students' CXC mathematics performance and teachers' content knowledge, pedagogical content knowledge, and mathematical knowledge. Also, I felt that in adding the participants' voice to the data mix, a more indepth and a richer set of explanations would emerge. These explanations came after carefully scrutinising the quantitative analysis of the mathematical knowledge section of the booklet provided (see Appendix 5) and focusing the discussion with the question: "how would you explain the lack of correlation between Dominican students' CXC performance and their teachers' CK, PCK, and combined CK and PCK?"

Quantitative analysis.

Here, the analysis of the survey completed by 47 fourth and fifth forms mathematics teachers in Dominica is presented. It focuses on teachers' mathematics content and pedagogical content knowledge as reported in the year 2014 when the survey was conducted. This analysis makes use of three frequency tables which were created in version 22 of the IBM, SPSS Statistics software. Narratives are used to explain the salient features of these three tables. A statement regarding the use of three scatter plots is also presented. The scatter plots were used to help group participants, during the focus group discussion, identify any relatioships between students' 2014 CXC mathematics performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. The scatter plots can be found in Appendix 5 but are not presented here because their principal use was in helping group participants identify any relationship that they may see in the quantitative analysis.

Number of content courses taken.

Content courses taken refer to post-secondary mathematics courses taken by Dominican mathematics teachers. Because the numbers of post-secondary mathematics courses taken by these teachers vary widely, I decided to report the various numbers of courses taken as ranges. This allowed for easier interpretion of the analysis. Consequently, five ranges were used: 0 – 4, 5 – 9, 10 – 14, 15 – 19, and > 19 (more than 19). I decided to use the above ranges after reviewing the program requirements for an Associate Degree, including the Associate Degree in mathematics, offered by the Dominica State College (DSC) and the program requirement for the Bachelor of Education in Secondary Mathematics Education offered by the University of the West Indies (UWI) open campus: the two leading post-secondary educational institution in Dominica. To obtain an Associate Degree in any major at DSC, at least two mathematics courses must be taken and passed; at least four mathematics courses must be taken if Chemistry, Physics, or Computer Science is the major; and at least 10 mathematics courses must be taken if the major is mathematics (Dominica State College, 2014). The Bachelor of Education in Secondary Mathematics Education offered at UWI also requires a minimum of 10 mathematics courses (University of the West Indies, n .d). Further, Bachelor of Science in Mathematics programs, world wide, require more than 10 mathematics courses and a Master of Science in mathematics degree adds to the tally of post-secondary mathematics courses. Teachers who responded to the survey reported every type of mathematics qualification metioned above: Associate Degree, in mathematics and other majors; Bachelor of Education in Secondary Mathematics Education; Bachelor of Science in Mathematics; and Master of Science in Mathematics. Hence, the ranges were constructed to reflect the requiremets of the above mentioned mathematics qualification programs.

Table 4.1 shows that out of the 47 survey participants, 45 participants (95.7%) responded to the survey prompt **B.5**: *Indicate the number of post-secondary mathematics courses taken*. Thirty-three respondents (73.3%) had taken less than 10 post-secondary mathematics courses indicating that their area of concentration was not in mathematics.

Twelve respondents (26.7%) had taken 10 or more post-secondary mathematics courses which indicate that their area of concentration was mathematics.

Number of CK Courses		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – 4	20	42.6	44.4	44.4
	5 - 9	13	27.7	28.9	73.3
	10 - 14	6	12.8	13.3	86.7
	15 - 19	3	6.4	6.7	93.3
	> 19	3	6.4	6.7	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		

Table 4.1: Number of post-secondary math content courses taken by teachers

Number of pedagogical content courses taken.

Pedagogical content courses taken refer to education courses specific to the teaching of mathematics taken by Dominican mathematics teachers. Because the quantity of mathematics pedagogical content courses offered by teacher education programs are usually limited to less than ten (Dominica State College, 2014; University of the West Indies, n .d), I decided to report the various numbers of courses taken as ungrouped quantities. DSC mathematics teacher education program require a minimum of four mathematics PCK courses (Dominica State College, 2014) while UWI Bachelor of Education in Secondary Mathematics Education program require a minimum of six mathematics PCK courses University of the West Indies, n .d).

Table 4.2 shows that all forty-seven (47) survey participants (100%) responded to the survey prompt **B.6**: *Indicate the number of mathematics content pedagogical courses taken*. Thirty-two respondents (68.1%) had taken less four PCK courses; less than the minimum number of PCK courses required to complete a teacher training grogram offered by any of the two leading post-secondary educational institutions in Dominica – DSC and UWI. Three respondents (6.4%) had taken either four or five PCK courses; sufficient to complete a teacher training program with DSC, and 12 respondents (25.5%) had taken six or more PCK courses; sufficient to complete a teachers training program with either DSC or UWI. That is, only 31.9% of the respondents had taken sufficient PCK courses to complete formal teachers training at any of the two leading post-secondary education institution in Dominica.

No. of PCK courses	Frequency	Percent	Valid Percent	Cumulative Percent
0	19	40.4	40.4	40.4
1	8	17.0	17.0	57.4
2	4	8.5	8.5	66.0
3	1	2.1	2.1	68.1
4	1	2.1	2.1	70.2
5	2	4.3	4.3	74.5
6	1	2.1	2.1	76.6
7	1	2.1	2.1	78.7
8	3	6.4	6.4	85.1
9	5	10.6	10.6	95.7
12	1	2.1	2.1	97.9
14	1	2.1	2.1	100.0
Total	47	100.0	100.0	

Table 4.2: Number of math pedagogical content courses taken by teachers

Combined number of content and pedagogical content courses taken.

The combined number of mathematics content and mathematics pedagogical content courses taken by participants in this study constituted their mathematical knowledge. Therefore, this sub-section presents the results for participants' mathematical knowledge. The quantity of courses representing teachers' mathematical knowledge were presented in ranges using similar categories as that used to analyse teachers' mathematics content knowledge. This was fitting because the greater number of courses came from teachers' mathematics content knowledge and the numbers from teachers' mathematics PCK, when added, did not significantly alter the range of the number of couses taken by teachers.

Table 4.3 shows that out of the forty-seven (47) survey participants, forty-five (45) participants' (95.7%) participants' responces to the survey prompts **B.5** and **B.6** could be combined**.** The combined responses constitute the mathematical knowledge of respondents. Thirty respondents (66.7%) had taken less than 14 mathematical knowledge courses; the minimum required to complete a teacher training program with DSC or UWI. The remaining 33.3% had taken the required number of mathematical knowledge courses to complete a teacher training program at any of the two leading post-secondary educational institution in Dominica.

Combined CK and PCK Courses		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – 4	17	36.2	37.8	37.8
	5 - 9	10	21.3	22.2	60.0
	10 - 14	3	6.4	6.7	66.7
	15 - 19	4	8.5	8.9	75.6
	20 - 29	9	19.1	20.0	95.6
	> 29	2	4.3	4.4	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		

Table 4.3: Combined number of math content and pedagogical content courses taken by teachers

Qualitative Analysis.

This section presents focus group participants' explanations on any relationship, or lack of, between Dominican students' CXC mathematics performance and fourth and fifth forms teachers' mathematics content knowledge, pedagogical content knowledge, and mathematical knowledge. It specifically addresses the focus group participants' thoughts on the survey data related to teachers' mathematics content and pedagogical content knowledge. Three frequency tables with accompanying bar-charts and three scatter plots (see Appendix 5) were presented and discussed with group participants. The bar-charts and scatter plots were given to participants as visual aids to help them make sense of the data. After a brief discussion focused on clarifying aspects of the data, participating teachers were then invited to share their thoughts. The collection of the themes and quotes which follow was driven by the question: how would you explain the lack of correlation between Dominican students' CXC performance and their teachers' CK, PCK, and mathematical knowledge (combined CK and PCK)? Three themes are identified: (a) Effects of teachers' content and pedagogical knowledge, (b) Factors constraining teachers' pedagogical practices, and (c) Student's poor foundation.

Theme 1: Effects of teachers' content and pedagogical knowledge.

There was a general consensus among group participants that Dominica's secondary mathematics teachers have the necessary mathematics content knowledge to teach mathematics at the secondary school level. There was also a general consensus, however, that these same Dominican teachers' mathematics pedagogical content knowledge is very limited and affected their teaching of mathematics in several ways. Teachers argued that one way that this lack of pedagogical content knowledge (PCK) affected teachers' practice is in their inability to bring their advance mathematics content down to the level of students in a way that allow them to understand it. As one teacher puts it:

…I think that probably has to do with the fact that people that just have the content courses……actually every time they take the content course they get further and further away from where their students are thinking. Their students thinking is on one level and the more content the person takes as they gain more understanding they also get to – unto a higher plane than their students and although they may know a lot of math content there is a big difference in teaching that content and to…you get further and you are not able to bring it to the level of our – the students… (Teacher A, February 2015).

Another argument that participating teachers presented is that teachers' apparent lack of pedagogical content knowledge affected their ability to engage all students during mathematics instruction. Group participants reported that mathematics instructions were often teacher centred and were usually geared towards some students, thus ignoring the needs of others. This lack of engagement that teachers reported is captured in the following quotes:

…they do not do a lot of diagnostic work as teachers and we really don't pay much attention to what the students – their learning styles or anything like that – we are more thinking about teacher, teacher, teacher, me, me, me, me – how I feel comfortable teaching…(Teacher B, February 2015).

…you have a certain group of children that you plan your lesson for and you say – if Michael learns my lesson today, YES!!! Because is Michael I expect to get my one (1) or my two (2)… (Teacher C, February 2015).

A third consequence of teachers' lack of or limited pedagogical content knowledge, as reported by teachers, was on the motivation of students. Group participants lamented that students were not motivated to learn mathematics. One participant recognised, and was supported by others, that this lack of motivation was as a result of teachers not using stimulating classroom strategies. It was suggested:

…so maybe if we are able to use the different methods – the pedagogical content knowledge – then they become motivated… (Teacher D, February 2015).

Theme 2: Factors constraining teachers' pedagogical practices.

Participants reported having to work under a number of constraints which restricted their use of proper pedagogical practices. They claimed that the fear of losing authority and control in the classroom is one such constraining factor. According to participating teachers, this factor prevented teachers from fully involving students in lessons and restricted the use of discovery type lessons. Thus, teachers resorted to mundane, traditional type lessons; often lessons designed within the teachers' comfort zones. One participant puts it this way:

…we are very teacher centred in the Caribbean and anytime we start to go into being student centred we find that we losing like a lot of the authority in the classroom and some teachers do not want to give up their authority. They want to be the bido, the fountain of knowledge, the one the children run to… (Teacher B, February 2015).

Teachers also claimed that time, when considered in relation to preparing students for the CXC examination, was another major constraint. Participants stated:

…and another thing is CXC is an external exam and most of the time a lot of rote learning comes into it so we teach to the exam and a lot ... some of the children don't understand the process and the mathematical understanding because all we do we just skim through…(Teacher B, February 2015).

…and CXC the test we teach in a rote way. I know by time…because of time limit we feel constrained…we got to cover the syllabus so we sometimes go through it in a very rote way but that's why sometimes kids don't do well on their exams…(Teacher A, February 2015).

…when you get to CXC… yes you want to, to give them the opportunity to sit down and get that wow moment and at the back of your head you say, okay get it, we don't have time. I want you to get to that wow moment but get it in ten minutes, fifteen minutes… (Teacher E, February 2015).

Theme 3: Student's poor foundation.

Participants were adamant that students enter fourth and fifth forms with very weak foundations in key aspects of mathematics and this made it very difficult for teachers who teach the CXC syllabus. This is a constraint in itself but received sufficient attention in the group discussion to be considered as a separate theme. Group participants generally felt that most of the mathematics problems faced by students and teachers at the secondary school level stem from what is happening, or not happening, at the primary school level. This sentiment is captured in the following:

…our problem is not when the children get to fifth form or fourth form. The foundation has not been set; the pedagogy of primary school mathematics needs to be developed so that by the time they get to CXC … (Teacher E, February 2015).

…and the elephant is that most of our teachers in primary school do not have pass mark in mathematics that is number one and they are teaching the students where the foundation is laid… so they do not know the mathematics content… they do not have the foundation… you now have to start to build the foundation from scratch… (Teacher B, February 2015).

…in Dominica more primary school teachers are trained yet when the students come into our secondary school system there is a myriad of problems with the students and what they have in there…(Teacher F, February 2015).

…some of the teachers they downright say that some of the math classes that is on the time table but they don't teach it, they rather teach English or Social Studies… (Teacher C, February 2015).

Discussion.

The results analysed and presented in the section "Mathematical Knowledge" of this document clearly show that advance mathematics content knowledge is an essential but not sufficient criterion for the effective teaching of mathematics (Davis & Renert, 2014). The explanations that teachers provided, under the three identified themes above, showed that Dominican fouth and fifth forms teachers had the content knowledge necessary to teach the mathematics they were called upon to teach. Group participants' explanations showed, however, that other factors, such as CXC examination constraints and poor foundational knowledge among students, seriously affected how mathematics lessons were taught at the fourth and fifth forms levels; mostly through direct instruction and rote learning. Focus group participants argued that these practices were prevalent beacause of a lack of PCK among fourth and fifth forms mathematics teachers. This may be explained by looking through the lens of Davis and Renert (2014) and Ma (1999).

Davis and Renert (2014) argued that mathematics content learnt at colleges and universities does not necessarily prepare individuals for teaching mathematics. This is because these pure content courses are usually designed and taught by university faculties divorced from teaching departments (Proulx & Simmt, 2011) and their aim is to produce individuals who are proficient in mathematics. Proficiency in mathematics does not guarantee an in-depth understanding of mathematics content and/or knowing the content in different ways; two requisites for the effective teaching of mathematics (Davis & Renert, 2014). Hence, although Dominican fourth and fifth forms mathematics teachers may have had the CK required to teach mathematics at the fouth and fifth forms levels, without the accompanying PCK, they may not have had sufficient mathematical knowledge to teach the mathematics content effectively.

According to Ma (1999), effective teaching of mathematics refers to teaching which goes beyond showing students how to solve routine mathematics problems through the use of well-practiced algorithms, but also allow students to develop an understanding of why these algorithms work, and how they can be connected to other mathematics concepts. The analysis of group participants' contributions and the themes identified from those contributions along with the analysis of teachers pedagogical content knowledge show that Dominica's secondary mathematics teachers may be deficient in their ability and drive to present mathematics lessons as described by Ma (1999). Research suggests that for the effective teaching of mathematics, teachers require both advanced content knowledge (CK) and pedagogical content knowledge (PCK) of mathematic concepts (Even, 1993; Baumert et al., 2010; & Watson and Harel, 2013).

It must be noted that over 68% of Dominican fourth and fifth form mathematics teachers who participated in the study had taken less than four mathematics PCK courses; the lowest requirement for formal teacher training programs suggested by Dominica's leading post-secondary education institutions – DSC and UWI. How this relates to students' CXC mathematics performance was explained by the qualitative analysis in which teachers pointed to a deficiency in Dominican fourth and fifth forms mathematics teachers' ability and/or willingness to design and develop lessons that will motivate and engage students of varying abilities. They claimed that teachers were, in fact, contented to lay blame on teachers of mathematics at the primary school level, who they claim do a very poor job of preparing students with the foundational mathematics needed at the secondary level.

Teaching Strategies

Presented in this section are the results for the frequency of use of 12 recommended teaching strategies employed by fourth and fifth forms mathematics teachers in Dominica. It specifically presents the analysis of how frequently survey participants used twelve recommended teaching strategies–quantitative analysis, followed by the analysis of the focus group participants' discussions – qualitative analysis – in relation to the results from the quantitative analysis.

The quantitave analysis in this section makes use of 12 frequency tables; one table for each stategy. Each frequency table have five columns showing: frequency of use– how frequently, on a scale of 0 – 5, teachers use a particular strategy; frequency–the number of teachers reported a frequency of use; percent–the percentage of teachers reporting a frequency of use; valid percent–the percentage of teachers reporting a frequency of use accounting for survey participants who did not respond to that prompt; and cumulative percent–the running total of the valid percent.

The qualitative analysis makes use of themes supported by quotes from teachers. Each identified theme is supported with teachers' direct quotes and presents group participants' explanations and thoughts on the frequency of use of 12 teaching strategies used in the teaching of mathematics in Dominican secondary schools. These themes and quotes form the basis of the discussion used to integrate the quantitative and qualitative data sets for this domain. More specifically, the qualitative data collected through the group discussion, provided the basis for teachers' explanations for any relationship, or lack of, which they observed between students' CXC mathematics performance and teachers' frequency of use of these 12 recommended teaching strtegies. These explanations came after carefully scrutinising the quantitative analysis of the strategy domain of the booklet provided (see Appendix 5) and focusing the discussion with the question: "since our teachers have been using all of the recommended teaching strategies with high frequency, how would you explain our dismal CXC mathematics performance over the years?"

Quantitative Analysis.

In this section, the frequency of use of 12 recommended teaching strategies reported by 47 fourth and fifth forms mathematics teachers who completed the survey are analysed and presented separately. The 12 frequency tables used in this analysis were all created in version 22 of the IBM, SPSS Statistics software. As indicated earlier, the first column of each frequency table reported the frequency of use; interger values ranging from zero to five represented different frequency of use. Following is the interpretation of each interger value: 0 = not at all; 1 = very infrequent; 2 = infrequent; 3 = somewhat frequent; 4 = frequent; and 5 = very frequent. Teachers' responses were in reply to the survey prompt C.2: with a scale of 0 – 5 where 5 represent very frequent and 0 represent not at all, indicate the frequency with which you use these strategies. Accompanying narratives explain the salient features of each frequency table.

Exploration and investigation.

Table 4.4 shows that all 47 participants responded to the question of teachers involving students in activities where they explore and investigate mathematics ideas. All respondents reported on the frequency of using this strategy in their mathematics instruction. Ten reported that they used the strategy infrequently or very infrequently in their instruction and 37 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 78.7% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	6.4	6.4	6.4
	2	7	14.9	14.9	21.3
	3	17	36.2	36.2	57.4
	4	17	36.2	36.2	93.6
	5	3	6.4	6.4	100.0
	Total	47	100.0	100.0	

Table 4.4: Teachers' use of explorations and investigations in teaching mathematics

Use students' prior knowledge.

Table 4.5 shows that all 47 participants responded to the question of teachers using students' prior knowledge to help shape classroom instructions. All respondents reported on the frequency of using this strategy in their mathematics instruction. Two reported that they used the strategy infrequently in their instruction and 45 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 95.7% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	4.3	4.3	4.3
	3	4	8.5	8.5	12.8
	4	20	42.6	42.6	55.3
	5	21	44.7	44.7	100.0
	Total	47	100.0	100.0	

Table 4.5: Teachers' use of students' prior knowledge in teaching mathematics

Use manipulatives and visual aids.

Table 4.6 shows that all 47 participants responded to the question of using manipulatives and visual aids during classroom instructions. All respondents reported on the frequency of using this strategy in their mathematics instruction. Four reported that they used the strategy infrequently in their instruction and 43 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 91.5% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	4	8.5	8.5	8.5
	3	13	27.7	27.7	36.2
	4	19	40.4	40.4	76.6
	5	11	23.4	23.4	100.0
	Total	47	100.0	100.0	

Table 4.6: Teachers' use of manipulatives and visual aids in teaching mathematics

Use real world problem solving activities.

Table 4.7 shows that all 47 participants responded to the question of using real world problem solving activities during classroom instructions. All respondents reported on the frequency of using this strategy in their mathematics instruction. One reported that they used the strategy infrequently in their instruction and 46 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 97.9% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	2.1	2.1	2.1
	3	11	23.4	23.4	25.5
	4	20	42.6	42.6	68.1
	5	15	31.9	31.9	100.0
	Total	47	100.0	100.0	

Table 4.7: Teachers' use of real world problem solving activities in teaching mathematics

Integrate math with other content.

Table 4.8 shows that all 47 participants responded to the question of integrating the content from other subjects with mathematics. All respondents reported on the frequency of using this strategy in their mathematics instruction. Five reported that they used the strategy infrequently or very infrequently in their instruction and 42 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 89.4% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.1	2.1
	2	4	8.5	8.5	10.6
	3	15	31.9	31.9	42.6
	4	21	44.7	44.7	87.2
	5	6	12.8	12.8	100.0
	Total	47	100.0	100.0	

Table 4.8: Teachers' integration of other subject contents with mathematics concepts

Use technology.

Table 4.9 shows that 45 participants responded to the question of using technology in the teaching of mathematics. Not all respondents reported on the frequency of using this strategy in their mathematics instruction. Nineteen reported that they used the strategy infrequently, very infrequently, or not at all in their instruction and 26 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 57.7% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	6.4	6.7	6.7
	1	8	17.0	17.8	24.4
	2	8	17.0	17.8	42.2
	3	17	36.2	37.8	80.0
	4	8	17.0	17.8	97.8
	5	1	2.1	2.2	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		

Table 4.9: Teachers' use of technology in the teaching of mathematics

Students use oral and written expressions.

Table 4.10 shows that 46 participants responded to the question of students using both oral and written expressions during the teaching of mathematics. All respondents reported on the frequency of students using this strategy during mathematics instruction. Seven reported that students use this strategy infrequently or very infrequently and 39 reported that students use this strategy somewhat frequently, frequently, or very frequently during instruction. That is, 80.5% of the respondents reported that students use this strategy somewhat frequently or higher during mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	5	10.6	10.9	15.2
	3	11	23.4	23.9	39.1
	4	16	34.0	34.8	73.9
	5	12	25.5	26.1	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		

Table 4.10: Teachers' use of oral and written expressions in the teaching of mathematics

Encourage collaboration.

Table 4.11 shows that all 47 participants responded to the question of teachers encouraging students in collaborative activities. All respondents reported on the frequency of using this strategy in their mathematics instruction. Four reported that they used the strategy infrequently or very infrequently in their instruction and 43 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 91.5% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	2	4.3	4.3	8.5
	3	8	17.0	17.0	25.5
	4	24	51.1	51.1	76.6
	5	11	23.4	23.4	100.0
	Total	47	100.0	100.0	

Table 4.11: Teachers' use of collaborative activities in the teaching of mathematics

Use students' errors.

*Table 4.*12 shows that all 47 participants responded to the question of teachers using students' errors to help develop mathematical understanding. All respondents reported on the frequency of using this strategy in their mathematics instruction. Four reported that they used the strategy infrequently or very infrequently in their instruction and 43 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 91.5% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.1	2.1
	2	3	6.4	6.4	8.5
	3	9	19.1	19.1	27.7
	4	24	51.1	51.1	78.7
	5	10	21.3	21.3	100.0
	Total	47	100.0	100.0	

Table 4.12: Teachers' use of students' errors in the teaching of mathematics

Offer challenging activities to all students.

*Table 4.*13 shows that 46 participants responded to the question of offering challenging mathematics activities to all students. All respondents reported on the frequency of using this strategy in their mathematics instruction. Five reported that they used the strategy infrequently or very infrequently in their instruction and 41 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 89.1% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.2	2.2
	2	4	8.5	8.7	10.9
	3	16	34.0	34.8	45.7
	4	20	42.6	43.5	89.1
	5	5	10.6	10.9	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		

Table 4.13: Teachers' use of challenging activities in the teaching of mathematics

Use a variety of problems.

*Table 4.*14 shows that all 47 participants responded to the question of teachers using a variety of problems to help develop mathematical understanding. All respondents reported on the frequency of using this strategy in their mathematics instruction. Nine reported that they used the strategy infrequently or very infrequently in their instruction and 38 reported that they used this strategy somewhat frequently, frequently, or very frequently in their instruction. That is, 80.9% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	7	14.9	14.9	19.1
	3	13	27.7	27.7	46.8
	4	17	36.2	36.2	83.0
	5	8	17.0	17.0	100.0
	Total	47	100.0	100.0	

Table 4.14: Teachers' use of a variety of problems in the teaching of mathematics

Use relevant context.

*Table 4.*15 shows that 46 participants responded to the question of using context that are relevant to students in their teaching of mathematics. All respondents reported on the frequency of using this strategy in their mathematics instruction. Eight reported that they used the strategy infrequently or very infrequently in their instruction and 38 reported that they used this strategy somewhat frequently, frequently, or very frequently in their

instruction. That is, 82.6% of the respondents reported that they used this strategy somewhat frequently or higher in their mathematics teaching sessions.

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	6	12.8	13.0	17.4
	3	16	34.0	34.8	52.2
	4	19	40.4	41.3	93.5
	5	3	6.4	6.5	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		

Table 4.15: Teachers' use of relevant context in the teaching of mathematics

Table 4.4 to *Table 4.15* inclusive along with accompanying bar-charts were presented to focus group participants, during the group discussion (see Appendix 5). The information provided in these frequency tables and the trends presented in the bar-charts provided the substance for the group discussion. Through their contributions during the group discussion, teachers provided their explantions for any relationship they observed between students' CXC mathematics performance and teachers' frequency of use of the 12 recommended teaching strategies. Following is the analysis of the focus group participants' contributions.

Qualitative Analysis.

Teaching strategies employed is a critical factor in determining students' performance (Alberta Learning, 2002). How critical are the strategies used by Dominica's fourth and fifth forms mathematics teachers is the subject of this section. Here, the views and explanations of focus group participants are presented. The analysed survey data regarding the frequency of use of twelve recommended teaching strategies provided the substance for the focus group discussion which was focused using the question: "since our teachers have been using all of the recommended teaching strategies with high frequency, how would you explain Dominica's dismal CXC mathematics performance over the years?" From the discussion which ensued, three themes were identified: (1) teachers were aware of the recommended strategies but did not use them; (2) teachers used strategies inappropriately thus rendering them ineffective; and (3) teachers were not fully aware of the meaning of some strategies. Following are discussions on these themes supported by quotes from group participants.

Theme 1: Teachers were aware of the recommended strategies but did not use them.

Group participants said that they were aware that the twelve teaching strategies presented in the survey were all good strategies but admitted that they seldom used them because of many constraints. Participants cited constraints such as time, students lacking the foundation from primary school and lower secondary, and students' behaviour. On the question of time, participants cited the pressures of preparing students to take the CXC mathematics examination as very limiting. Teachers claimed that using these strategies consumes a lot of time which they cannot afford in fourth and fifth forms. The following quotes capture the essence of participants' contributions on the constraints that time placed on them:

…I know I should be using them but I also will have to admit we all know the constraints of teaching fourth and fifth forms CXC and how we are worried about the time… (Teacher A, February 2015).

…we also get very constrained about time when we get to fourth and fifth forms and all of these do take more time, I think we would agree… (Teacher B, February 2015).

The following quotes typify participants' views on the lack of foundation in the use of these strategies when students enter fourth and fifth forms:

…but again if we start teaching those things from the primary school level then when it comes to the secondary it is not about teaching them how to think critically now it is about them using their critical thinking skills to do what they have to do. So it's gonna take less time…they are already used to it… (Teacher D, February 2015).

…I think a lot of these strategies…if the students, especially the students, are not use to using them in primary school and first form, second form, third form trying to get them to use investigation and exploration methods in fourth and fifth forms is more frustrating than anything else…(Teacher E, February 2015).

The constraint of student behaviour as cited by group participants was derived from utterances such as this:

…okay, but the real constraint is…you come to the classroom you might have a perfect lesson whatever happens a child might interrupt your introduction and at the back of your head you want to finish or…you might have a little issue on your mind and somebody throw you off…you just go back to your normal way of teaching… (Teacher F, February 2015).

Theme 2: Teachers use strategies inappropriately thus rendering them ineffective.

Group participants expressed their belief that some teaching strategies are better suited to certain mathematics topics and their use should be avoided in some topics. Participants explained, however, that some teachers used certain strategies in lessons where they are not appropriately suited, thus, rendering these strategies ineffective. Participants' views are expressed in the following quotes:

…really and truly they have the strategies they are teaching it but it is not reaching the students and you wonder…some strategies are to be used for certain topics and you have to use the strategy that can best fit the topic…some teachers they, like they have a small bowl of strategies so you just pick one and you just put it in the lesson… (Teacher B, February 2015).

…but sometimes you just choose any strategy and you just use it and sometimes it just makes a mess of the lesson… (Teacher D, February 2015).

Participants said that in some cases teachers do not execute the strategies properly. Reference was made to a discovery lesson followed by a reference to the strategy of using students' error.

…you want to do a discovery lesson but then you know the time comes when they keep on rushing the students, all the time, we need to get this and we need to get…and then after a while they maybe find taking too long, try to help them, little clues and whatever…(Teacher C, February 2015).

…a student may answer a question, the response may be correct or wrong and right away as teachers we respond and say very good to correct. We don't give another student a chance to

be able to look at that answer, say whether it is correct, what is wrong with that answer if it is wrong…instead we as teachers are coming in too quickly giving answers…(Teacher F, February 2015).

Group participants, again, claimed time constraint as the reason for their failure to effectively execute the recommended teaching strategies.

Theme 3: Teachers did not have a full understanding of the meaning of some strategies.

It was the general consensus of group participants that some teachers did not fully understand the true meaning and significance of some of the teaching strategies given in the survey. Group participants said that teaching strategies such as variety of questions, using students' errors, open ended versus closed ended questions, and use of technology are some strategies that were possible misinterpreted by survey participants. Group participants had these to say:

…you know the famous power point presentations. So many of us may want to do power point presentations but all we do is just place it on the screen and run through the, through the slides and we don't get the students to interact and we okay. That is supposed to be done under use of technology but it is not being used effectively… (Teacher D, February 2015).

…use a variety of problems; are you sure the teachers didn't think is the questions in the math textbook…like simple little problems? (Teacher B, February 2015).

…like for example that one with students' errors. If a child make a simple mistake and I just say: Jane that is not the answer, the teacher probably saying, yes, I point out errors in the classroom…and then like when you think about problem solving and problems, most of the questions you give are closed ended problems…we really don't give our students open ended problems for them to come up with a myriad of ways to solve them… (Teacher B, February 2015).

One participant said that it is because Dominican teachers:
…lack reflection, we don't, we don't do enough reflection so probably that questionnaire was the first time teachers were thinking back…I don't think we do that enough so given the

opportunity to evaluate our teaching strategies…we think we do more than we actually do… (Teacher E, February 2015).

Discussion.

The focus group discussion, which provided teachers' explanations on the analysis of the frequency of use of the 12 recommended teaching strategies, provided reasons for the poor performances that Dominican students have experience on CXC mathematics examinations over the past 11 years: Over the past 11 years Dominican students received on average approximately 40% pass-rate on CXC mathematics examinations. Group participants contended that some teachers were aware of recommended teaching strategies but either did not use them or use them inappropriately. Group participants also contended that some teachers did not have a full understanding of the meaning of some of these recommended teaching strategies and hence did not use them as frequently as reported. The effects of such lack of and/or inappropriate use of recommended teaching strategies can be explained through the lens of Kline (1995); D'Ambrosio, Johnson, & Hobbs (1995); and Choike (2000).

Kline (1995); D'Ambrosio, Johnson, & Hobbs (1995); and Choike (2000) all argued for the use of multiple strategies in the teaching of mathematics. These researchers recognised that different students thrive under different conditions and in the words of Kline (1995), "nothing works every time, everywhere, for everyone. No single strategy, approach or technique works with all students" (p. 22). These researchers are thus proposing that students be exposed to several teaching strategies if all students are to be given a chance to succeed in mathematics. With an average CXC pass rate of approximately 40% over the past 11 years (2004 – 2014), the majority of Dominican students are clearly not succeeding in mathematics.

Take for instance the use of technology as a strategy. Group participants, who were very experienced teachers, spoke at length about the use of power point presentations as using technology in teaching. During that discussion no mention was made of the critical use of spreadsheets and graphing utilities as they relate to problem solving. Neither was any mention made of software such as Geometer's Sketchpad, Algebra Expresser, and LOGO which are used to explore and construct mathematical ideas (D'Ambrosio, Johnson, & Hobbs, 1995).

Another strategy that is critical to students' learning that was reported as misunderstood is the use of students' error in teaching. The consensus was that teachers answered positively to this strategy because they pointed out to students when they were correct or wrong, and may even have told students why their answers were wrong. Using students' errors, however, goes beyond these simple responses to include questioning students' thinking process used to obtain solutions. That is, students' errors must be explored if misconceptions are to be ironed out and full understanding obtained (D'Ambrosio, Johnson, & Hobbs, 1995).

Other critical areas where deficiencies were exposed are: in offering an enriched curriculum and challenging activities to all students, in using a variety of problem-solving experiences, and in the use of manipulatives. Group participants clearly stated that they did not offer open ended problems to their students, catered only for a selected few in their classrooms, and questioned the use of manipulatives in upper secondary classrooms. These utterances clearly indicate awareness but limited use of many of the twelve recommended strategies discussed.

Beliefs about the Teaching of Mathematics

The analysed results of the fourteen beliefs statements surveyed are presented in this section. Both the results of the quantitative and the qualitative analyses are presented. The quantitative analysis of the surveyed data is presented first, followed by the qualitative analysis of the focus group discussion. The quantitative analysis makes use of four tables separating the statements into categories. The first column of each respective table shows the belief statements; the next five columns show the ratings strongly agree, agree, neutral, disagree, and strongly disagree respectively; the seventh, final, column shows the number of participants who have not responded to a statement. The number of participants who subscribed to a particular rating is placed in the appropriate cell in the respective table and narratives are used to highlight salient features about tables. As done previously, the qualitative analysis makes use of themes and quotes from teachers, with each identified theme being supported with teachers' direct quotes. Finally, a discussion integrates the quantitative and qualitative analyses for this section.

Quantitative Analysis.

Fourteen belief statements were sub-divided into four categories: (a) unhealthy beliefs (Garofalo, 1989)–study habits, test taking strategies, and classroom behaviours teachers use and encourage students to use as a means of coping with challenges in the mathematics classroom; (b) world views (Gales and Yan, 2001)–behaviourism and constructivism; (c) constructivism (Chung, 2009)–teachers' views on important aspects of teaching mathematics based on constructivism, and (d) belief about students' ability and teachers' strategies (Bossé, Adu-Gyamfi, and Cheetham, 2011)–how teachers perceive students' ability to do mathematics and the effectiveness of their teaching strategies. It was fitting to use these categories because the 14 statements were adapted from Garofalo (1989), Gales and Yan (2001), Chung (2009), Bossé, Adu-Gyamfi, and Cheetham (2011) who discussed the effects of unhealthy beliefs, world views, constructivism, and teachers' beliefs about students' ability to do mathematics respevtively. Each theme is presented in a separate table containing the relevant belief statement. Each statement was analysed separately with attention being paid to the number/percentage of respondents who agreed, disagreed, and were neutral.

Unhealthy beliefs.

This category is based on Garofalo (1989) and three statements fell into this category of teachers' belief. They are presented in *Table 4.16* below.

- Forty-four participants responded to the statement regarding mathematical thinking. Thirty-nine respondents (88.6%) agreed to some extent that mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures; three respondents (6.8%) disagreed to some extent; and two respondents (4.5%) were neutral.
- Forty-six participants responded to the statement regarding the mathematics that is worth knowing. Four respondents (8.7%) agreed to some extent that only the mathematics to be tested is important and worth knowing; 39 respondents (84.8%) disagreed to some extent; and three respondents (6.5%) were neutral.
- Forty-four participants responded to the statement regarding the importance of adhering to textbooks prescribed methods and strategies. Thirteen respondents (29.5%) agreed to some extent that it is important to adhere to prescribed methods

and strategies; 20 respondents (45.5%) disagreed to some extent; and 11 respondents (25%) were neutral.

Statements	Number of Teachers					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No response
Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures.	17	22	2	3	0	3
Only the mathematics to be tested is important and worth knowing. For example, formulas are important, but their derivations are not.	0	4	3	21	18	1
It is important to adhere to the methods and strategies prescribed in textbooks.	1	12	11	14	6	3

Table 4.16: Unhealthy beliefs about teaching mathematics

Table 4.16 shows 134 responses out of a possible total of 141 responses to these belief statements. Fifty-six responses (41.8%) were in agreement and 62 responses (46.3%) were in disagreement with the statements. Sixteen responses (11.9%) were neutral. These statistics indicate that in general, Dominican secondary mathematics teachers were more or less evenly divided in response to Garafalo's unhealthy beliefs (Garafalo, 1989).

World views.

This category is based on Gales and Yan (2001) and two statements fell into this category of teachers' belief. According to Gale and Yan, the first statement in *Table 4.17* represents a behaviourist world view while the second statement represents a constructivist world view.

- Forty-five participants responded to the statement regarding a nine step sequence for teaching mathematics. Twenty-four respondents (53.3%) agreed to some extent that this nine step sequence is the best approach to teaching mathematics; four respondents (8.9%) disagreed to some extent; and 17 respondents (37.8%) were neutral.
- Forty-five participants responded to the statement regarding creating and enabling environment. Thirty-six respondents (80%) agreed to some extent that creating an enabling environment is the best approach to teaching mathematics; zero respondents (0%) disagreed; and nine respondents (20%) were neutral.

Statements	Number of Teachers					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No response
The sequence: (a) gaining attention, (b) informing the learner of the objective, (c) stimulate recall, (d) present stimulus material, (e) provide learning guidance, (f) elicit the performance, (g) provide feedback, (h) assess performance, and (i) enhance retention and transfer; is the best approach to teaching mathematics.	8	16	17	3	1	2
Creating an educational environment that permit students to assume responsibility for their learning, building on students' existing knowledge base, extending students' repertoire of cognitive and metacognitive strategies, and correcting specific learning problems; is the best approach to teaching mathematics.	10	26	9	0	0	2

Table 4.17: Teachers' world views on the teaching of mathematics

The analyses of the statements in *Table 4.17* indicte that Dominican secondary mathematics teachers believed primarily in the constructivist world view. This is supported by the 80% who agreed to the second statement in the table. This, however, is not a clear cut divide because 53% also showed a leaning towards the behaviourist world view.

Constructivism.

This category is based on Chung (2009) and seven statements fell into this category of teachers' belief. These statements presented in *Table 4.18* below represent teachers' beliefs about different facets of the constructivist approach to teaching mathematics.

- Forty-six participants responded to the statement regarding the importance of real life applications in teaching mathematics. Thirty-two respondents (69.6%) agreed to some extent that real life application is most important in teaching and learning mathematics; one respondent (2.2%) disagreed to some extent; and 13 respondents (28.2%) were neutral.
- Forty-five participants responded to the statement regarding the importance of process in teaching mathematics. Twenty-nine respondents (64.4%) agreed to some extent that process is most important in teaching and learning mathematics; two

respondents (4.4%) disagreed to some extent; and 14 respondents (31.1%) were neutral.

- Forty-six participants responded to the statement regarding the use of concrete materials when explaining mathematics concepts. Thirty respondents (65.2%) agreed to some extent that concrete materials are needed to explain mathematics concepts; two respondents (4.3%) disagreed; and 14 respondents (30.4%) were neutral.
- Forty-six participants responded to the statement regarding the use of concrete materials when introducing new mathematics concepts. Twenty-one respondents (45.7%) agreed to some extent that concrete materials are needed when introducing new mathematics concepts; 10 respondents (21.7%) disagreed; and 15 respondents (32.6%) were neutral.
- Forty-six participants responded to the statement regarding the use of concrete materials to illustrate abstract mathematics concepts. Thirty-seven respondents (80.4%) agreed to some extent that concrete materials are needed when illustrating abstract mathematics concepts; one respondent (2.2%) disagreed; and eight respondents (17.4%) were neutral.
- Forty-six participants responded to the statement regarding the importance of conceptual understanding in teaching mathematics. Forty-four respondents (95.7%) agreed to some extent that conceptual understanding is very important in teaching and learning mathematics; one respondent (2.2%) disagreed to some extent; and one respondent (2.2%) was neutral.
- Forty-five participants responded to the statement regarding the importance of procedural knowledge in teaching mathematics. Forty-one respondents (91.1%) agreed to some extent that procedural knowledge is very important in teaching and learning mathematics; one respondent (2.2%) disagreed to some extent; and three respondents (6.7%) were neutral.

Statements	Number of Teachers					
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**No response**
Real life application is the very important in teaching and learning mathematics.	9	23	13	1	0	1
Process is the very important in teaching and learning mathematics.	7	22	14	2	0	2
To teach mathematics, we need to explain concepts using concrete materials.	4	26	14	2	0	1
When introducing a new concept, we always need to use concrete objects.	4	17	15	10	0	1
I need to help children develop abstract knowledge from concrete examples by illustrating the concept using concrete models.	10	27	8	1	0	1
In mathematics teaching, conceptual understanding is very important.	20	24	1	1	0	1
In mathematics teaching, procedural knowledge is very important.	14	27	3	1	0	2

Table 4.18: Teachers' beliefs regarding important aspects of constructivism

Table 4.18 shows 320 responses out of a possible total of 329 responses to these belief statements. Two hundred and thirty-four responses (73.1%) were in agreement and 18 responses (5.6%) were in disagreement with the statements. Sixty-eight responses (21.3%) were neutral. These statistics indicate that in general, Dominican secondary mathematics teachers strongly believed in most facets of the constructivists approach to teaching mathematics.

Belief about students' ability and teachers' strategies.

This category is based on Bossé, Adu-Gyamfi, and Cheetham (2011) and two statements fell into this category of teachers' belief. These statements presented in *Table 4.19* below represent teachers' personal beliefs about students and students' response to their teaching.

- Forty-four participants responded to the statement regarding their instructional methods. Thirty-eight respondents (86.4%) agreed to some extent that students learn mathematics well through their instructional methods; one respondent (2.3%) disagreed to some extent; and five respondents (11.3%) were neutral.

- Forty-six participants responded to the statement that all normal students can learn mathematics. Thirty-nine respondents (84.8%) agreed to some extent that all normal students, both boys and girls, can learn mathematics; three respondents (6.5%) disagreed to some extent; and four respondents (8.7%) were neutral.

Statements	**Number of Teachers**					
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**No response**
I feel my students learn mathematics well through my instructional methods.	10	28	5	1	0	3
All [normal] students, both male and female, can learn mathematics.	23	16	4	2	1	1

Table 4.19: Teachers' beliefs regarding students' mathematics ability

The analyses of the statements in *Table 4.19* show that Dominican secondary teachers believe that all students can learn mathematics and learn it well through their teaching practices. It is unclear what criteria was used by these teachers to determine that students learn mathematics well through their teaching since CXC grades for the past 11 years shows an average pass rate of approximately 40%.

Qualitative Analysis.

Four themes were identified from the analysis of group discussion relevant to teachers' beliefs about the teaching of mathematics. To focus the discussion, participants were presented with the analysis of the survey data regarding teachers' beliefs about the teaching of mathematics. Participants were told that the analysis of teachers' beliefs indicated that teachers had a very positive attitude towards the teaching and learning of mathematics. This, however, is not reflected in Dominica's CXC mathematics performances. To drive the discussion, the following question was asked: "are these beliefs reflected in the teaching practices of Dominica's secondary mathematics teachers?" In response, participants expressed views that: (a) mathematics teachers should start with a group of students from first form and move with them through secondary grades all the way to fifth form, (b) mathematics success is varied and teachers must work to different end goals, (c) students, and not teachers, are to blame for their failures in mathematics, and (d) too much mathematics content is taught at the secondary school level. These themes are different from the categories presented in the quantitative analysis but reflect the thinking of group participants. These themes are presented below.

Theme 1: Teachers moving with students through the grades.

Group participants complained that students who get to them in fourth and fifth forms seldom have the requisite math needed to tackle the concepts they are to learn for CXC examination. Group participants believed that this issue can be addressed and rectified if mathematics teachers are made responsible for a group of students as they enter first form. That is, participants believe that if teachers move with a group of students from first to fifth form, they will ensure that students learn the foundational mathematics required for fourth and fifth form work. One participant stated:

…what we should do is try a year to take a group of students from first form to fifth form and really see if it different in the end and the results the students get for CXC…because sometimes when you come to the fourth form the previous knowledge that they had you find it lacking…so what you end up doing is spending a class or two or three teaching the pre-req before you can even start to teach… (Teacher B, February 2015).

Participants pointed out that the consequences for students not having the requisite foundation are: (a) students are rushed in order to complete the CXC syllabus and (b) teachers are forced to use direct instruction at the expence of other recommended teaching strategies. Such sentiments are captured in:

…I look at the children…they too busy having to rush through…for example to us chalk and talk direct instruction is what we always fall back on when the rubber hits the road… (Teacher B, February 2015).

Theme 2: The measure of mathematics success.

Two sub-themes were identified under this theme; students' measures of success and teachers' measures of success. Participants expressed two different ways of measuring students' successes. (a) Success based on students' CXC mathematics performances and (b) success based on students' personal improvements. On the question of CXC mathematics performances as a measure of students' success, teachers expressed mixed beliefs. Participants stated:

…we should focus on passing CXC because in the world out there is either you have a pass for CXC… in the Caribbean context is either you have a pass for CXC or you don't… (Teacher A, February 2015).

…There are some aspects of the CXC syllabus that are just not for some of my students, they are not going to use it, it doesn't relate to them at all, they should not be doing it, they should not be judge by it…(Teacher C, February 2015).

…there are some people that the math they need to learn is the math that they need to…be effective, second to be able to hold a job, and to be numerate, but they don't need to do vectors and matrices, they don't need to do higher level mathematics, quadratics and so…yes it's just knowledge that they learning and literally just for CXC… (Teacher F, February 2015).

On the question of measuring success by personal improvement, one participant expressed his/her belief as:

…I look at all of my students and I will tell one student if you can answer one question for CXC to me you pass. Your CXC grade might not say that, it might not reflect that, but I know that… (Teacher F, February 2015).

Participants also expressed their views on how they measure their own successes in teaching mathematics. Participants stated:

...as long as the students you think that will pass the subject they pass it, we measure our success, well me, I measure my mathematics success by that… (Teacher B, February 2015).

…well, well to be very honest with you, I mean at the ______ high school I give up on grading myself at the percentage pass for CXC… (Teacher F, February 2015).

Theme 3: It is the students' fault.

Participants expressed their firm belief that students' poor performance on CXC mathematics is the fault of students. Group participants claimed that students are not motivated to work at mathematics and do not make sufficient effort to learn the concepts taught to them. Participants said that teachers are well versed in deflecting blame from themselves unto the students instead of rethinking their methods and strategies. The following quotes highlight participants thinking:

…we think that is not you that is the problem. Most of…the majority of teachers…when you go in the classroom then afterwards you talk to them and so the first thing they mention is… you see how the students them are behaving, you see their attitude?...we always seem to deflect and we never seem to look back and realise things like probably I did not teach the children because they were not motivated by my method…we never do that, we never do self-reflection, we always try to pass the buck unto the children…(Teacher B, February 2015).

…there are students when you meet them, when you assess them you know they need four years to pass… (Teacher E, February 2015).

…and am thinking like, how can I motivate children who do not do what they are supposed to do when they have…that's why I said earlier, you can come with the most perfect lesson but the motivation…(Teacher F, February 2015).

Theme 4: Too much mathematics content.

Some participants were of the opinion that too many different pieces of mathematics content are being taught at the secondary level. Teachers felt that mathematics content covered at the secondary level should to be concepts that lay the foundation for college and university mathematics. It was also felt that once students have a solid grasp of numbers; other mathematics content can easily be learned at a later stage in students' academic life. One participant puts it this way:

…to me there are some basic things we need to learn as a condition in math and then you can teach your…you can learn it anytime… as long as you have the structure. So I don't see the reason why I should be teaching piece of that, piece of this, piece of this. What I want CXC to do is just de foundation like we know what the foundation is in math, it is numbers and then the children will channel themselves to the areas… (Teacher B, February 2015).

The question to be asked here, however, is: were these pieces of content spoken about meant to be integrated?

Discussion.

Are these beliefs reflected in the teaching practices of Dominica's secondary mathematics teachers? The evidence presented in the analysis of discussion of group participants when compared to the analysis of the relevant survey data, suggest that in general, the teaching practices of Dominican secondary mathematics teachers do not reflect their beliefs about the teaching and learning of mathematics. The analysis of most, if not all, belief statement revealed that the teachers in question presented a positive attitude towards mathematics teaching. However, evidence gathered from the discussion painted a different picture of what actually took place in classrooms. The balance of this discussion focuses on particular cases where discrepancies between belief and practice existed.

First, in the category "*Unhealthy beliefs"*, teachers reported mixed beliefs about the teaching of mathematics. The greater percentage of participants disagreed with two out of the three statements in this category that Garofalo (1989) argued represent unhealthy beliefs. The greater percentage of participants, however, agreed to one statement that Garofalo argued represents an unhealthy belief. The analysis of the group discussion shows, however, that Dominican fourth and fifth forms teachers' teaching efforts were focused on students' being able to remember and apply mathematics facts, rules, and formulas; concentrated exclusively on mathematics that were tested by CXC; and in most cases employed the methods illustrated in textbooks. According to Garofalo (1989), these practices reflect unhealthy beliefs which are contray to what the majority of teachers reported in the survey. Put differently, Dominican fourth and fifth forms teachers' practice did not reflect their beliefs in this category.

Second, in the categories "*World views"* and *"Constructivism",* discrepancies also existed between teachers' beliefs and their instruction practices. The responses of teachers to the two statements in the world view category indicated that most of Dominica's fourth and fifth forms mathematics teachers believed in the basic principles of constructivism in that creating an educational environment that permit students to assume responsibility for their learning, building on students' existing knowledge base, extending students' repertoire of cognitive and metacognitive strategies, and correcting specific learning problems is the best approach to teaching mathematics. Contrary to this reported belief, however, group participants reported that students were exposed to a different learning environment.

According to the analysis of the group discussion, students were rushed through mathematics concepts as teachers attempted to complete the CXC mathematics syllabus. Participants also reported that direct instructions were the most widely used teaching strategy and students' correct responses to a set number of close-ended questions was teachers' priority. This is contrary to what teachers reported in the constructivism category.

In the constructivism category, teachers reported very positive responses to belief statements in that their agreement rates on six out of the seven statements ranged from 64% to 96% while one statement had an agreement rate of forty-six percent 46% and a disagreement rate of 22%. However, instead of planning and executing mathematics lesson to reflect these beliefs, teachers cited several reasons/constraints why they are forced to abandon their beliefs and revert to practices where students are simply told and/or shown the steps in solving mathematics problems. Time constraint, lack of students' motivation, and poor students' behaviour are among the most prevalent of these constraints cited by group participants.

Third, discrepancies exist between teachers' reported beliefs about students' ability to do mathematics. Approximately 85% of the survey participants agreed that all normal students, both male and female, can learn mathematics. Yet, group participants clearly expressed the view that only a selected few students can pass CXC mathematics. Group participants went further to state that they catered for only that selected few when planning and delivering their mathematics lessons and rated their school's success, at CXC mathematics, on the success of the few who they perceived had the mathematics ability.

Futher, discrepancies also exist between teachers' reported beliefs about students' learning of mathematics through their teaching methods. Approximately 86% of the survey participants agreed that their students learn mathematics well through their instructional methods. This is contrary to students' CXC mathematics results which show that on average only 43% of students passed CXC mathematics between 2004 and 2014.

Across Domains Discussion.

Across the three domains – mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematics, one central theme with three sub-themes were identified. The central theme is: in Dominican secondary schools, students are not sufficiently exposed to sustained, good teaching practices. The sub-themes identified are: (a) limited pedagogical content knowledge affects teachers' practice, (b) CXC mathematics examination constrains teachers' practice, and (c) poor mathematics foundation limits the use of recommended teaching strategies. These sub-themes are used to explore and explain the central theme.

The utterances of group participants pointed to a weakness in pedagogical content knowledge (PCK) of Dominican fourth and fifth forms mathematics teachers. This weakness is linked to and was identified by teachers' utterances in regards to teachers being unable to: plan lessons which cater for all students, select appropriate teaching strategies, properly execute planned strategies, and integrate mathematics concepts among content strands. Looking through the lens of Davis and Renert (2014), these are clear symptoms of a practice deficient of teachers' mathematical knowledge. Teachers' mathematical knowledge is constituted by both mathematics content knowledge and mathematics pedagogical content knowledge. Since, the consensus is that teachers have the necessary content knowledge to teach secondary mathematics, the deficiency, therefore, is in their PCK.

Group participants claimed that preparing students to take the CXC mathematics examination at the end of fifth form is a major constraint to their choice of teaching strategies. Teachers also claimed that time is a serious factor because recommended teaching strategies such as explorations and investigations consume a lot of time and with the amount of content to be covered for CXC mathematics they are forced to rush through the syllabus. Other reasons given by group participants put the blame on the students. Teachers claimed that students are not motivated and they are not able to get through to them with their best planned lesson. Students' misbehaviour was also cited as a factor which prevented teachers from executing their perfectly planned lessons. Whether these reasons are legitimate or not, what is significant at this juncture is that Dominican secondary mathematics students were not sufficiently exposed to good teaching strategies.

Teachers also complained that students entering fouth and fifth forms were poorly prepared at the lower secondary and primary school levels. Claims were made that students entered fourth and fifth forms without the requisite content knowledge nor do they possess any knowledge of or skills in using strategies such as investigations and explorations and solving open ended problems, among others. Teachers argued that this apparent lack of requisite knowledge and skils made it difficult for them to teach using the recommended strategies and keep up with the demands of preparing students for the CXC mathematics examination. This may be another legitimate concern, but it limits students' exposure to recommended teaching strategies.

Support: Analysis and Discussion

The analysed results of the twelve statements regarding support available to and/or used by Dominican fourth and fifth forms teachers are presented in this section. Presented is a quantitative analysis which makes use of three tables which sub-divided the statements into three (3) categories: in-service courses and workshops; basic resources; and human resource. I decided on these categories based on the information solicited by the statements. After reading the statements, key words and/or phrases were identified in each statement and these words and/or phrases were used to categorise the statements. In the "*In-service courses and workshops*" category the key phrase used to identify the statements placed in that category was 'in-service courses and workshops'; in the *"Basic resources"* category the key word and phrase used to identify the statements placed in that category were 'resources', 'texts or reference books'and 'computer'; and in the *"Human resources"* category the key words and phase used to identify the statements placed in that category were 'assistance'and 'partner with'. The first column of each table contained the relevant statements.

Each table contains seven columns. The first column shows the statements regarding the type of support available and/or how they were used by mathematics teachers; the next five columns show the ratings strongly agree, agree, neutral, disagree, and strongly disagree respectively; the seventh, final, column shows the number of participants who have not responded to a statement. The number of participants who subscribed to a particular rating is placed in the appropriate cell and narratives are used to highlight salient features about each table. Each category is analysed to give an overall picture depicting where Dominican teachers stand on the availability of support.

In-service Courses and Workshops.

Three statements fell in this category and are presented in *Table 4.20* below.

Statements	Number of Teachers					
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**No response**
Mathematics in-service courses or workshops have been facilitated by my school in the last year	4	16	9	11	3	4
Mathematics in-service courses or workshops have been facilitated by Ministry of Education in the last year.	7	26	5	6	0	3
I have attended at least one available mathematics in-service courses or workshops in the last year.	14	23	2	6	0	2

Table 4.20: Availability and use of in-service courses and workshops

In respect to the overall availability and use of in-service courses and workshop, 132 responses were recorded. Ninety responses (68.2%) showed that teachers either agreed or strongly agreed that in-service courses or workshops were available to and attended by them. Sixty-eight percent is a fair rating and reflects positively on both the education institutions which provide such in-service training and the teachers who availed themselves of these training. Education is a life-long process and when teachers avail themselves of opportunities to improve their practice it augers well for the teachers, their students, and the institution (s) which they serve. Hopefully, the effects of this healthy practice will soon be reflected in Dominican students' mathematics performances and fortunes at CXC examinations.

Basic Resources.

Five statements fell in this category and are presented in *Table 4.21* below.

Statements	Number of Teachers					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No response
The school has resources available to support the teaching and learning of mathematics.	5	24	12	4	1	1
I have access to multiple texts or reference books for mathematics.	16	27	1	2	0	1
I am aware of resources outside my school that can support my teaching and learning of mathematics	8	22	9	5	1	2
I do use resources outside the school that support my teaching and learning of mathematics.	6	27	9	3	0	2
I have access to computer technology that can be used in the teaching of mathematics.	14	18	6	3	5	1

Table 4.21: Availability and use of basic resources

In respect to the overall availability and use of resources, 228 responses were recorded. One hundred and sixty-seven responses (73.2%) showed that teachers either agreed or strongly agreed that resources were available to and used by them. Seventy-three percent is a good rating and reflects positively on both the institutions which make these resources available and the teachers who make use of these resources. Teaching resources are vital to good and sustained teaching practices. Mathematics educators do not always, nor are they expected to, know all of the content and/or pedagogical practices necessary for good teaching. Efficient educators, however, know where to find and how to avail themselves of the mathematical knowledge they require at the time it is required. When appropriately and timely used, good resources can provide invaluable help to educators.

Human Resources.

Four statements fell in this category and are presented in *Table 4.22* below.

Statements	Number of Teachers					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No response
I know where to go when I need assistance with my mathematics teaching.	16	24	3	2	0	2
I do partner with mathematics teachers from within my schools when planning for my teaching of mathematics.	14	25	2	3	0	3
I do partner with mathematics teachers from other schools when planning for my teaching of mathematics.	2	8	13	18	3	2
I have access to mathematics or mathematics education experts if assistance is needed in planning and/or teaching areas in mathematics.	7	22	11	4	2	1

Table 4.22: Availability, access, and use of human resources

In respect to the overall availability, access, and use of human resources, 179 responses were recorded. One hundred and eighteen responses (66%) showed that teachers either agreed or strongly agreed that human resources were available and they had access to and/or used these resources. Sixty-six percent is a fair rating and reflects positively on both the institutions which make these human resources available and the teachers who make use of these resources. Working with peers is critical in any educational setting. Peers usually present colleagues with fresh perspectives of educational issues, can be a great source of help in areas of weakness, and provide moral support to colleagues who are plagued with doubts from time to time. Hence, it is a very healthy practice for mathematics teachers to team up with colleagues both within and outside of their school; pooling their mathematical resources in order to enhance their lesson planning and delivery.

Summary.

This chapter presented the analyses and discussions of three domains of the main research question and the support system available to Dominican teachers. The quantitative analysis of the mathematical knowledge domain provided the substance for the focus group discussion in relation to that domain and the analysis of the group discussion showed that Dominican secondary mathematics teachers were weak in pedagogical content knowledge.

This deficiency in PCK affected teachers' ability to plan and execute lessons which cater for the needs of all students.

For the teaching strategy domain, the quantitative analysis again provided the substance for the focus group discussion on the frequency of use of 12 recommended teaching strategies. The qualitative analyses for this domain showed that teachers did not use the strategies, used them inappropriately, or in some instances did not understand these strategies. The qualitative analysis was based on the autorances of six mathematics teachers who were highly experience teaching mathematics in the Dominican context and who were, in most cases, heads of the Mathematics Department at their respective school. In my view, they were best positioned to comment on the state of mathematics teaching and learning in Dominica.

In the belief about the teaching of mathematics domain, the quantitative analysis showed that teachers were very positive in their responses to the belief statements. In most cases, teachers agreed or strongly agreed with the statements that presented positive beliefs and responded with disagree and strongly disagree when the statement presented a belief in a negative way. The analysis of the group discussion showed, however, that in general the practices of these teachers did not reflect their beliefs.

These analyses all led to a central theme supported by three sub-themes. The central theme indicated that Dominican secondary students were not sufficiently exposed in a sustained way, to recommended strategies for the teaching of mathematics. Teachers defended their practice by claiming that they are constrained by time as they prepare students for the CXC mathematics examination and that students' lack foundational mathematical knowledge. A good support system, however, is reported by teachers. Teachers presented fair to good rating in all three identified categories of the support system. If used properly, this support system may help teachers overcome many of their pedagogical weaknesses.

Chapter 5: Conclusion

The purpose of this study was to obtain an explanation from Dominican secondary mathematics teachers on any relationship between Dominican students' performance on CXC mathematics examinations and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics. Mathematical knowledge in this study refers to both teachers' knowledge of mathematics subject matter – content knowledge (CK) and recommended ways for teaching the various strands of mathematics–pedagogical content knowledge (PCK). The 12 recommended strategies were proposed by D'Ambrosio, Johnson, and Hobbs (1995) and the different categories of beliefs were adapted from the work of Garofalo (1989)–unhealthy beliefs; Gales and Yan (2001)–world views; Chung (2009)–constructivism; and Bossé, Adu-Gyamfi, and Cheetham (2011)–belief about students' ability and teachers' strategies. Performance was taken as students' achievement on the Caribbean Examination Council (CXC) mathematics examination which is normally taken by students as they exit secondary schools in most Caribbean countries. Dominica, a Caribbean island, was the site of the study and fourth and fifth forms mathematics teachers were the participants. The study is one of the first of its kind to be undertaken in Dominica and sought to provide a foundation for me and others in the field to build on. In laying such a foundation it was critical that the following questions were answered:

1. What mathematical knowledge did Dominican mathematics teachers take into secondary classrooms?
2. How frequently did Dominican secondary mathematics teachers employ recommended teaching strategies in their mathematics classrooms?
3. What were Dominican secondary mathematics teachers' beliefs about the teaching of mathematics and to what extent were their beliefs reflected in their teaching?

The answers to these questions provided the information needed to answer the main research question: "*In what ways will Dominican secondary mathematics teachers explain any relationship between students' CXC performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?"*

This chapter presents the study findings and their implications to the field of mathematics education. It specifically presents syntheses of the empirical findings in regards to the three questions listed above and a synthesis of the finding in regards to the main research question of the study. Also presented are the theoretical and policy implications of this study. Two recommendations for further study are also presented. The chapter ends with a final statement about the impact of the study and a statement on my personal commitment to mathematics education.

Empirical Findings

Major empirical findings are presented in the results and discussions chapter – chapter 4 within the respective domains: mathematical knowledge, teaching strategies, and beliefs about the teaching of mathematics. This section synthesizes these empirical findings to answer the three sub-questions of the study and the main research question. Each question is synthesized individually.

What mathematical knowledge did Dominican mathematics teachers take into secondary classrooms?

a. Weak pedagogical content knowledge: The analysis of group participants' discussions–qualitative analyses–described deficiencies in Dominican secondary mathematics teachers' ability to prepare and deliver lessons that catered for the needs of all students. Group participants pointed to the struggles that many Dominican fourth and fifth forms mathematics teachers had in capturing and holding the attention of students. Teachers complained of not being able to motivate students and admitted to preparing and delivering lessons that cater for the needs of a chosen few.

b. Fair content knowledge: all group participants said that Dominican secondary mathematics teachers knew the content that they were called upon to teach. This is supported by the quantitative analysis which showed that all respondents had at least a pass in CXC mathematics and most of the survey respondents had taken post-secondary mathematics courses.

How frequently did Dominican secondary mathematics teachers employ recommended teaching strategies in their classrooms?

Poor usage of recommended teaching strategies: the analysis of group participants' discussions indicated that the 12 recommended strategies investigated in this study were either not frequently used or were used poorly. This apparent lack of or poor usage of these teaching strategies was reflected in participants' claims that teachers' planning and delivery of lessons did not cater for students with varied mathematics abilities. By group participants' utterances, teachers relied on and turned to direct instructions to cope with the many constraints they faced in the mathematics classroom. In spite of this copping mechanism, however, students continue to perform poorly at CXC mathematics examinations.

What were Dominican secondary mathematics teachers' beliefs about the teaching of mathematics and to what extent were their beliefs reflected in their teaching?

a. Positive beliefs: based on the analysis of survey data, Dominican fourth and fifth forms mathematics teachers were rated very highly in regards to their beliefs about the teaching of mathematics. Such beliefs, however, must be reflected in the planning and execution of mathematics lessons in order for students' performance on CXC mathematics to improve.

b. Beliefs not reflected in practice: it is one thing to believe in something and it is a different thing to practice it: It is the practice of beliefs that is likely to bring about the results that a person desires. The analysis of the focus group discussions showed that to a large extent, the majority of Dominican fourth and fifth forms mathematics teachers did not practice, to a sustained degree, what they believed. The utterances of group participants indicated that instead of trying to allow students to achieve conceptual understanding, using materials and processes in which they believed in, teachers focused their teaching on covering the CXC mathematics syllabus. In so doing, the interest and needs of many students, contrary to stated beliefs, were not met.

In what ways do Dominican secondary mathematics teachers explain any relationship between students' CXC performance and teachers' mathematical knowledge, frequency of use of recommended teaching strategies, and beliefs about the teaching of mathematics?

A limited exposure to a variety of recommended teaching strategies, which goes contrary to teachers'stated beliefs, but fuelled by a weekness in teachers' pedagogical content knowledge, may be related to students' poor performance on CXC mathematics examinations. This is evident by analyses from all three domains, where a single disturbing feature about Dominican secondary mathematics teachers' practices emerged from the multitude of teachers' explanations given in response to the analysed quantitative data: Dominican fourth and fifth forms mathematics teachers failed to expose students, in a sustained way, to a variety of recommended teaching strategies. Analyses of of teachers' explanations offered in the focus group showed that, in general, teachers did not have the pedagogical content knowledge required to teach mathematics effectively to the groups of students they were called upon to teach and hence did not frequently use recommended teaching strategies. That is, although teachers clearly stated their beliefs in the use of sound pedagogical practices, by their own utterances, in general these beliefs were not reflected in their teaching practices. To cover for this lack, a number of constraints such as the pressures of CXC examinations, poor students' motivation, and poor students' readiness were cited as leading causes. While these may all be legitimate reasons which need to be investigated, they do not negate the eminent need for Dominican mathematics students to be exposed more frequently to recommended teaching strategies.

Theoretical and Policy Implications

The theoretical stance that advanced subject matter knowledge is a necessary but insufficient criterion for teaching (Davis & Renert, 2014) holds true. Mathematics teachers need more than knowledge of mathematics concepts to teach effectively. Of critical importance is the knowledge of, skills in, and willingness to use sound pedagogical practices related to different content strands in mathematics. Ma (1999) and this study support this theory. Ma argued that effective teaching goes beyond practices, such as direct instructions, which, in most instances, leads to surface learning; effective teaching involves practices which allow students to develop in-depth understanding of mathematics concepts. The empirical findings of this study showed that the prevalent use of direct instruction and the neglect of recommended strategies, fuelled by a lack of pedagogical content knowledge, did not lead to effective teaching. This is evident in the dismal performances on CXC mathematics recorded by Dominican students over the past eleven years.

Consequently, Dominica's education policy makers must rethink the minimum required mathematical knowledge for mathematics teachers in and/or entering classrooms. Evidence from several studies, including Ma (1999); Baumert et al. (2010); Watson and Harel (2013); and this study, seems to point to the fact that it is critical for mathematics teachers to know and use, appropriately, sound pedagogical strategies if students are to get maximum benefit from teaching. Further research, however, is needed to determine workable solutions to Dominica's mathematics teaching problems.

Recommendations for Future Research

Sound pedagogical practices are based on research and to develop programs with achievable targets aimed at generating workable solutions with local, regional, and possible global significance, these programs must by informed by carefully crafted research activities. Exploring the following as future research activities can facilitate the development of such programs.

- ***Concept study (Davis & Renert, 2014):*** involves groups of teachers meeting as communities of practitioners to study mathematics concepts of common interest. This practice has the potential of helping teachers, especially in-service teachers, to improve their mathematical knowledge and better understand the mathematical demands for teaching at various levels. Research into concept study in a Dominican context is needed if the most fitting programs are to be developed for Dominican mathematics teachers.
- ***CXC mathematics examination:*** teachers complained, profusely, about the constraints forced upon them by the CXC mathematics examination. A better understanding of the demands of CXC mathematics and how teachers are handling and/or mishandling those demands can help the powers that be make meaningful decisions where and when it matters most. Hence, research into CXC mathematics is critical.

Conclusion

It is commonly stated that once an individual knows the mathematics, they can teach it. This study has shown otherwise. Teaching mathematics requires a set of skills and knowledge – pedagogical content knowledge that if absent from teachers' repertoire their teaching of mathematics may not affect, positively, the students who need it most. That is, without the requisite knowledge and skills mathematics teachers will have difficulties planning and executing lessons which cater for the varied needs of all students. Further, this study shows that teaching strategies employed in mathematics classrooms are largely determined by teachers' pedagogical content knowledge, mathematics beliefs, and coping mechanisms. When pressured, Dominican mathematics teachers discard their beliefs about the teaching of mathematics and reverted to unhealthy practices. These unhealthy practices helped them to cope but left the students wanting. This bothers me and fuels my determination to make a difference through scholarly activities such as this.

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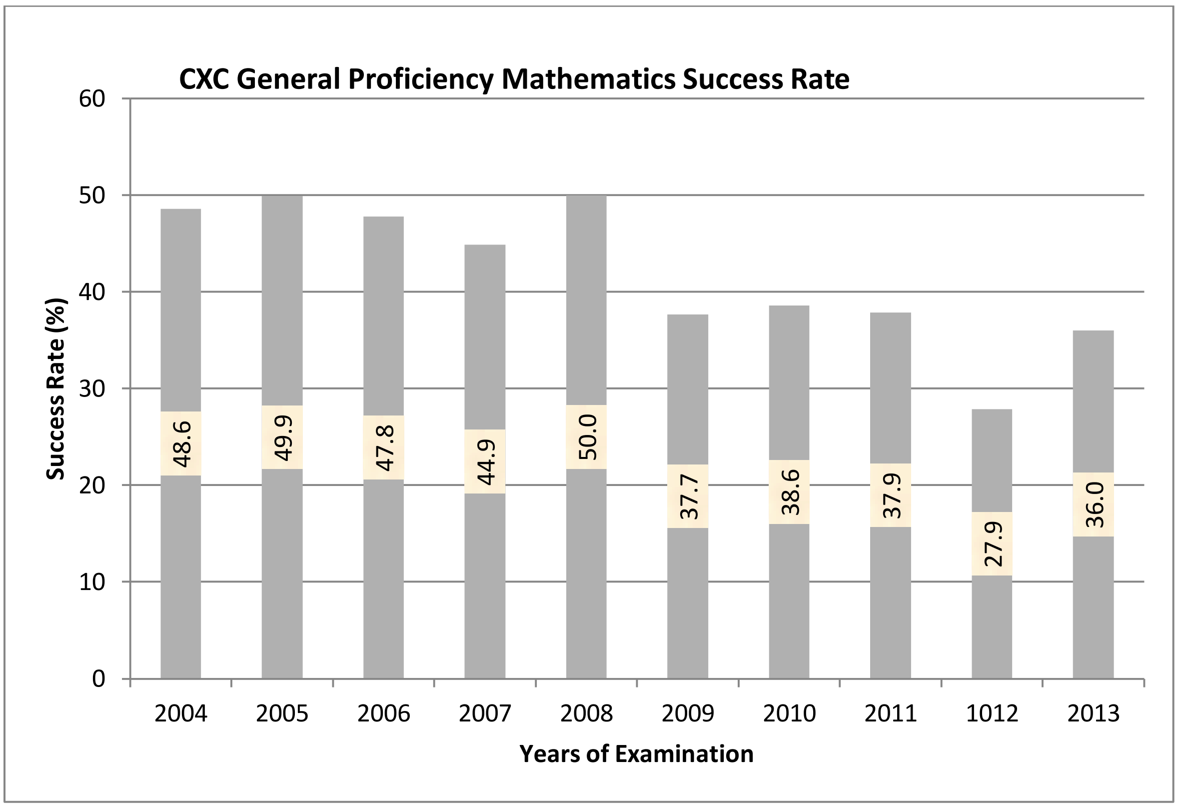
Appendices

Appendix 1: Ten years of CSEC Mathematics Performance

Bar-Chart showing the percentage passes of Dominicans at CXC General Proficiency Mathematics from 2004 to 2013 (Ministry of Education, 2012; 2013a).



Appendix 2: Secondary School Teacher Questionnaire

The purpose of this questionnaire is to collect information on mathematics teaching and learning in secondary schools in Dominica. This in turn will help to have a better understanding of how mathematics is taught and learnt and, the various means and challenges.

The information obtained will be used only for this purpose and will be kept in the strictest confidence. The data will be analysed by me and only my academic advisor at the University of Alberta apart from me will have access to the completed forms.

The completed forms will be kept in a locked cupboard at my home and will be burnt five years after the study.

Completing this questionnaire is voluntary and consent is assumed upon completion. Do not put your names on this form.

A: Demographics and other

A.1: *Indicate your gender (Please tick as appropriate).*

Gender:

Male	
Female	

A.2: *Indicate your age (Please tick as appropriate).*

Age:

Age in years	
Under 20	
20 - 29	
30 – 39	
40 – 49	
50 and above	

A.3: *Indicate your schools' average CXC mathematics performance for the last three years; 2012, 2013, 2014.* Average pass rate in CXC Mathematics:

____

B: Teacher Education and Qualification

B.1: *Indicate your level of teacher training (Please tick as appropriate)*

Training:

Untrained	
In training	
Trained	

B.2: *Years of teaching experience (please tick as appropriate)*

Experience:

Number of years	Teaching	Teaching Mathematics
Less than 5		
5 - 9		
10 or more		

B.3: *Indicate your highest level academic qualification* in Mathematics *(please tick as appropriate)*

Academic qualification:

Highest level attained	In Mathematics
CXC General Proficiency	
A-Level	
Associate degree	
First degree or higher	

B. 4: *Indicate the number of post-secondary mathematics courses taken (fill in as appropriate)*

Institutions Level	Number of Courses
Dominica State College and other like institutions	
A-Level (indicate 1)	
University undergraduate/graduate	

B. 5: *Indicate the number of mathematics content pedagogical courses taken (how to teaching a particular mathematics content area; e.g. Algebra). Put one if all you have taken is a general course in how to teach mathematics:* ___________________.

C: Mathematics Teaching and Learning

C.1: *Indicate your teaching levels (please tick all that relate to you)*

Teaching levels:

Fourth form (grade 11)	
Fifth form (grade 12)	

C.2: *With a scale of 0 – 5 where 5 represent very frequent and 0 represent not at all, indicate the frequency with which you use these strategies (please tick all that relate to you)*

Strategies	0	1	2	3	4	5
Exploration and investigations: involve students in activities where they explore and investigate mathematics ideas in and out of the classroom.						
Use students' prior knowledge: build instructions around students' world experiences.						
Use manipulatives and/or visual aids: Use physical objects, pictures, diagrams to help students make sense of mathematical concepts.						
Use real-world problem-solving activities: linking mathematics to the real world.						
Integrate mathematics with other content areas: apply acquired knowledge to new situations found in other subject areas and/or vice versa.						
Use technology: computer software, internet, interactive whiteboard, graphing calculators, etc.						
Students use oral and written expression: students made to give explanations in oral and other forms such as: writing, drawing, body actions, etc.						
Encourage collaborative problem solving: meaningful small group activities.						
Use errors to enhance learning: use students' incorrect responses to solicit students' misconceptions.						
*Offer and enriched curriculum and challenging activities. Exposed **all** students to cognitively demanding tasks.*						
Use a variety of problem-solving experiences: problems that can be solved in different ways; problems with more than one correct answer; problems that may involve decision making; problems that allow for different interpretations.						
Use culturally relevant materials: frame instruction in context related to students' interest: sports, arts, nature, cooking, etc.						

Do you use other strategies not listed above? If so, please describe them:

____

____

D. Mathematics Beliefs

Please indicate the degree to which you agree with each of the following statement.

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures.					
Only the mathematics to be tested is important and worth knowing. For example, formulas are important, but their derivations are not.					
It is important to adhere to the methods and strategies prescribed in textbooks.					
The sequence: (a) gaining attention, (b) informing the learner of the objective, (c) stimulate recall, (d) present stimulus material, (e) provide learning guidance, (f) elicit the performance, (g) provide feedback, (h) assess performance, and (i) enhance retention and transfer; is the best approach to teaching mathematics.					
Creating an educational environment that permit students to assume responsibility for their learning, building on students' existing knowledge base, extending students' repertoire of cognitive and metacognitive strategies, and correcting specific learning problems; is the best approach to teaching mathematics.					
Real life application is the most important in teaching and learning mathematics.					
Process is the most important in teaching and learning mathematics.					
To teach mathematics, we need to explain concepts using concrete materials.					
When introducing a new concept, we always need to use concrete objects.					
I need to help children develop abstract knowledge from concrete examples by illustrating the concept using concrete models.					
In mathematics teaching, conceptual understanding is very important.					
In mathematics teaching, procedural knowledge is very important.					
I feel my students learn mathematics well through my instructional methods.					
All [normal] students, both male and female, can learn mathematics.					

Do you have other strong beliefs about mathematics teaching and learning? If so, please describe them.

____

____

____

____

E. Support and Resources

E.1: Please indicate the degree to which you agree with each of the following statement

Statements	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Mathematics in-service courses or workshops have been facilitated by my school in the last year					
Mathematics in-service courses or workshops have been facilitated by Ministry of Education in the last year.					
I have attended at least one available mathematics in-service courses or workshops in the last year.					
I know where to go when I need assistance with my mathematics teaching.					
The school has got resources available to support the teaching and learning of mathematics.					
I have access to multiple texts or reference books for mathematics.					
I am aware of resources outside my school that can support my teaching and learning of mathematics					
I do use resources outside the school that support my teaching and learning of mathematics.					
I do partner with mathematics teachers from within my schools when planning for my teaching of mathematics.					
I do partner with mathematics teachers from other schools when planning for my teaching of mathematics.					
I have access to mathematics or mathematics education experts if assistance is needed in planning and/or teaching areas in mathematics.					
I have access to computer technology that can be used in the teaching of mathematics.					

E.2: Do you prepare students for CXC mathematics examination? If so, please describe your normal approaches.

Appendix 3: Information letter and consent form

Study Title: Performance in Mathematics: A Dominican Perspective

Research Investigator:
Christopher Charles
University of Alberta
Edmonton, AB, T6G 2G5
ccharles@ulaberta.ca
1 587 938 3757

Supervisor
Dr. Florence Glanfield
University of Alberta
Edmonton, AB, T6G 2G5
glanfiel@ualberta.ca
1 780 492 0743

Dear Participant,

In order to learn more about the way in which teachers' content knowledge, teaching strategies, and beliefs about mathematics affect students' performance in mathematics, I would like you to participate in this study. The information you provide will be used in the preparation of my Masters of Education thesis at the University of Alberta. The analyzed results of this research study may be published in an academic journal in Canada and it may also be made available to policy makers and ministry officials in Dominica.

Purpose
My research has the potential to benefit teachers, students and the Dominican community by identifying prevailing weaknesses and strengths in teachers' current practices, and providing policy makers and ministry officials with the foundation whereby corrective measures can be taken.

Study Procedures
This study will be done in two (2) phases. In phase one, I will ask you to complete a questionnaire designed to collect data about your content knowledge, teaching strategies, mathematics beliefs, and other relevant information. In phase two, a focus group discussion will be held with a small group of no more than ten (10) teachers where the findings of the survey will be looked at and possible explanations discussed.

Completion of the questionnaire is completely voluntary and should take no more than 20 minutes of your time. You will not be required to write your name or any other identifying mark on the form. By completing the questionnaire and turning it in I will assume you have given your completely voluntary and informed consent. You do not have to complete or turn in this questionnaire if you choose not to. However, once these sheets have been collected there will be no opportunity to withdraw your form.

Participation in the focus group discussion is also completely voluntary and will take about two (2) hours of your time. Your voices in discussions will be audio taped, hence, complete anonymity cannot be guaranteed. By completing and turning in a consent form I will assume you have given your completely voluntary and informed consent for participation in the focus group discussion. You do not have to complete or turn in this consent form if you choose not to and you can withdraw your participation at any time before or during the discussion. You will not, however, be able to withdraw any comments you have made during the group discussion since it will form part of the entire group comments.

Benefits

The intent of this research is to uncover some of the teacher-factors affecting teaching and learning of mathematics in Dominica. Once uncovered, teachers, principals, ministry officials and policy makers will be made aware of what exist and hopefully will take steps to correct the negatives and strengthen the positives. Teachers and in turn students will be the direct beneficiaries of the actions taken by education administrators.

In undertaking this project I am working towards acquiring and/or honing necessary research skills, and compiling and documenting salient teacher-factors that may be affecting Dominican secondary students' performance in mathematics. In Dominica little to no structured investigation has been conducted to look into ways that teachers impact students' performance. Once this research project is completed, the data will hopefully provide the foundation for further research and/or apprise Dominican education officials and policy makers, mathematics teachers and principals, and all other stake-holders, of the quality of teaching in Dominica's secondary mathematics classrooms.

It is not my intension to burden you in anyway during this study. Hence, if you have to travel to get to the place where the focus group discussion will be held, I will refund you your travel cost immediately after the session. I will also provide you with a snack at some point during or immediately after the session.

Risk

There is little to no risk to you in participating in this research. You may feel some anxiety in having to give information about your teaching practice. However, steps will be taken to ensure that no unauthorized person will have access to the data gathered during the survey and focus group discussion.

Confidentiality & Anonymity

As previously stated, I will use information collected in this study to prepare my Masters of Education thesis which maybe be published in part and/or given to policy makers and ministry officials in Dominica. At no point during the study or in its preparation and presentation will any individual or groups of individuals be identified.

Because complete anonymity cannot be guaranteed for neither the survey nor the group discussion, I will take all necessary precautions to keep the information you provide in strict confidence. The data will be analyzed by me and only my academic advisor at the University of Alberta apart from me will have access to the completed forms. The ethics research board at the University of Alberta may also have access if it so desire.

It is a policy of the ethics board that data be stored for a minimum of five years after a research study. In keeping to this requirement, I will be securing both the survey forms and audio-tape(s) in a locked cupboard in my apartment/at my home. I will burn these document five years after the study is completed.

Should you be interested in a copy of the report findings of the survey and group discussion, you can email me using my email address given above. I will email you an electronic copy.

If you have any further questions regarding this study, please do not hesitate to contact Christopher Charles at: email: ccharles@ualberta.ca, Tel.: 587 938 3757 (Alberta), Tel.: 767 276 5113 (Dominica)

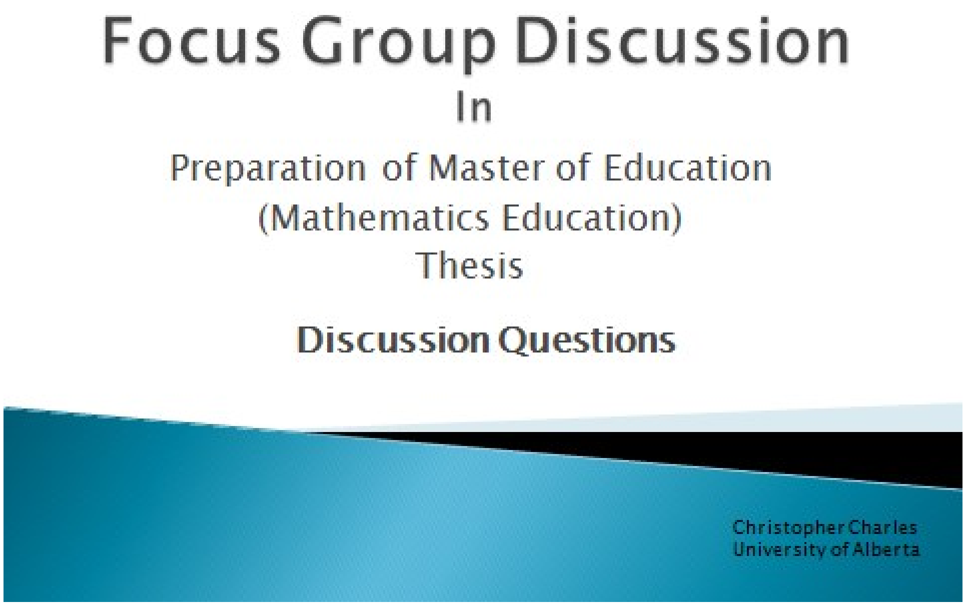
The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

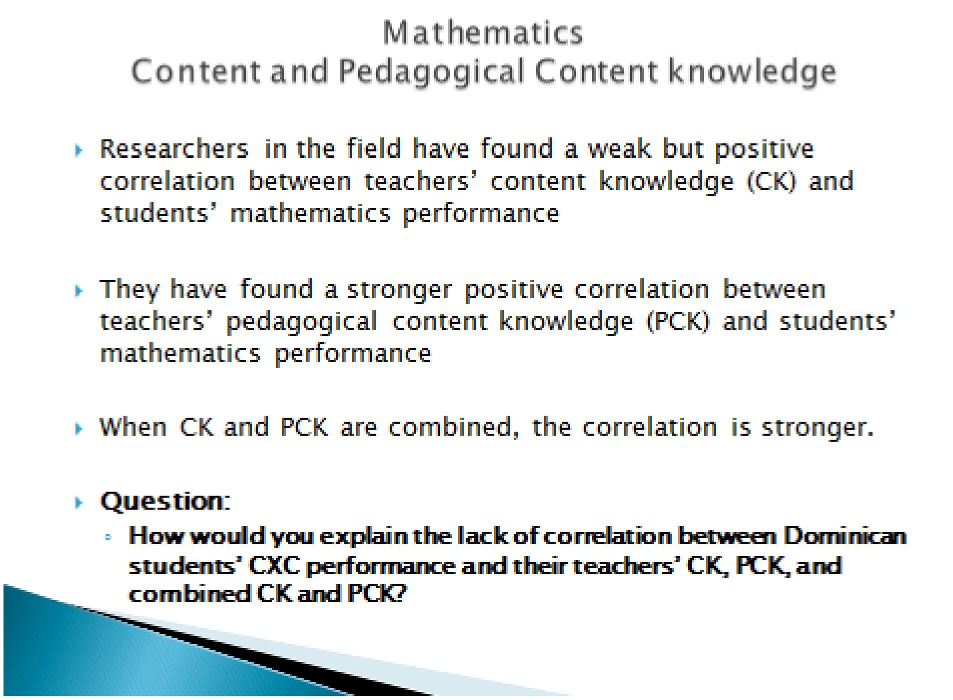
Consent Statement
I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I agree to participate in the research study described above and will receive a copy of this consent form. I will receive a copy of this consent form after I sign it.

____ ______________
Participant's Name (printed) and Signature Date

____ ______________
Name (printed) and Signature of Person Obtaining Consent Date

Appendix 4: Power point presentation used in group discussion





Teaching Strategies

- Teachers were asked to indicate the frequency with which they use 12 highly recommended strategies for teaching mathematics. Research literature shows that these strategies have positive influence on students' mathematics performance.

- Dominican mathematics teachers indicate that they use these strategies very frequently.

- Over the years Dominica's mathematics pass rate at CXC has been less than desirable.

- **Question:**
  - **Since our teachers have been using all of the recommended teaching strategies with high frequency, how would you explain our dismal CXC mathematics performance over the years?**

Beliefs About Mathematics

- The analysis of the data regarding teachers' beliefs about mathematics indicate that Dominica's secondary mathematics teachers have a very positive outlook regarding the teaching and learning of the subject.

- This, however, is not reflected in Dominica's CXC performance.

- **Question:**
  - **Are these beliefs reflected in the teaching practices of Dominica's secondary mathematics teachers?**

Open Discussion

- Please comment on any aspect of the data or study you wish to comment on.

Thank you for your time and effort.

It is much appreciated

Appendix 5: Focus Group Discussion Booklet

Focus Group Discussion
In

Preparation of Master of Education
(Mathematics Education)
Thesis

Analysis of Survey Data

Christopher Charles (Mr)
University of Alberta

Analysis of Dominica's 4th and 5th Form Mathematics Teachers Content Knowledge in 2014

Number of Post-Secondary CK Courses		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – 5	20	42.6	44.4	44.4
	6 - 10	13	27.7	28.9	73.3
	11 - 15	6	12.8	13.3	86.7
	16 - 20	3	6.4	6.7	93.3
	> 20	3	6.4	6.7	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		

Table 1: Number of post-secondary math content courses taken by teachers

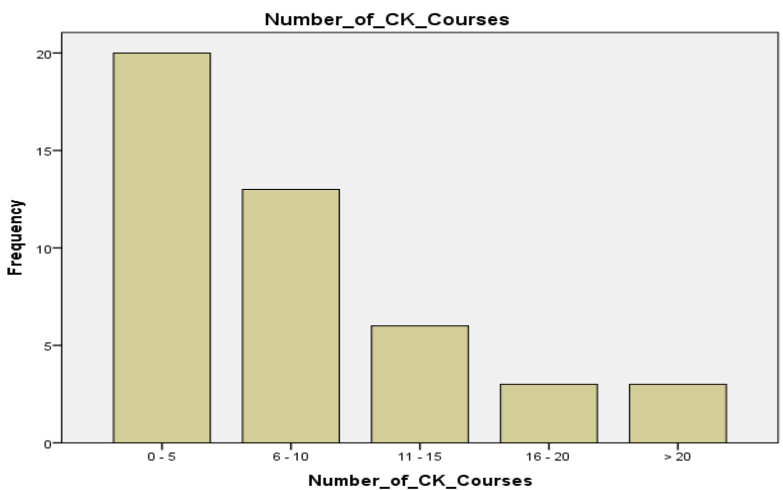


Figure 1: Bar chart showing number of post-secondary math content courses taken by teachers

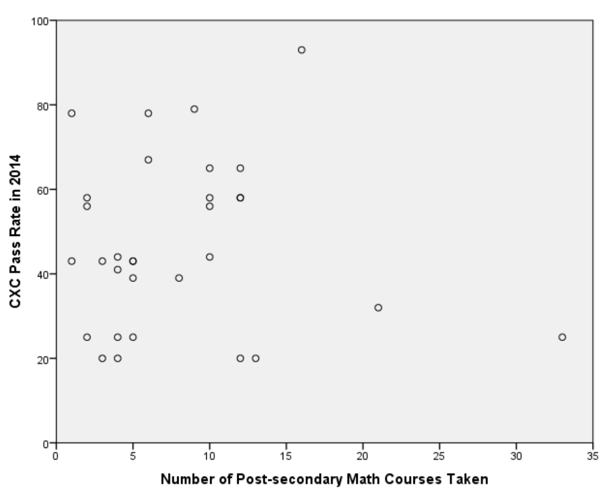


Figure 2: Scatterplot showing relation between students CXC performance and teachers' content knowledge

Analysis of Dominica's 4th and 5th Form Mathematics Teachers Pedagogical Content Knowledge in 2014

Number PCK Courses		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – 5	35	74.5	74.5	74.5
	6 – 10	10	21.3	21.3	95.7
	> 10	2	4.3	4.3	100.0
	Total	47	100.0	100.0	

Table 2: Number of math pedagogical content courses taken by teachers

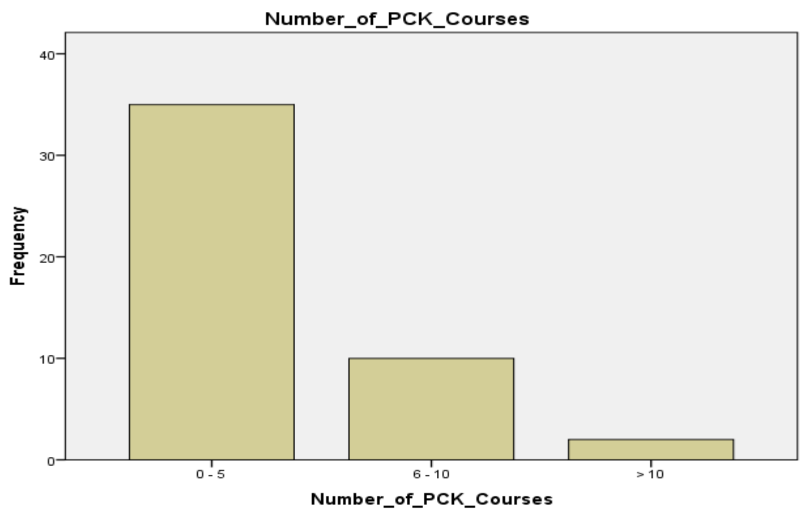


Figure 3: Bar chart showing number of math pedagogical content courses taken by teachers

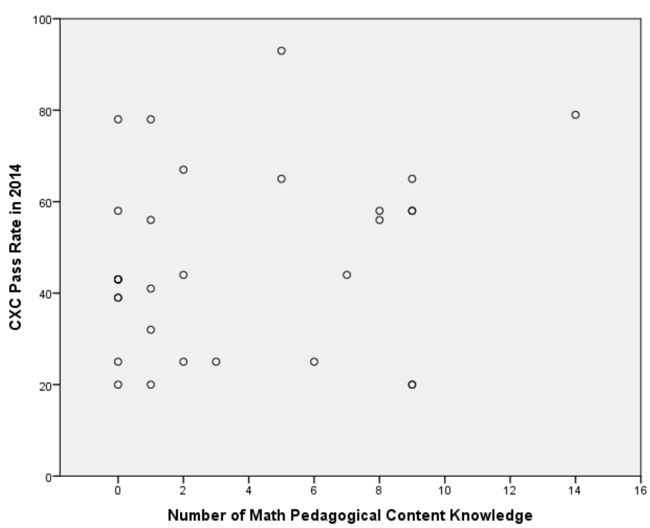


Figure 4: Scatterplot showing relation between students CXC performance and teachers' pedagogical content knowledge

Analysis of Dominica's 4th and 5th Form Mathematics Teachers Combined CK and PCK in 2014

Combined_CK_and_PCK

Combined CK and PCK Courses		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – 5	17	36.2	37.8	37.8
	6 - 10	10	21.3	22.2	60.0
	11 - 15	3	6.4	6.7	66.7
	16 - 20	4	8.5	8.9	75.6
	21 - 25	9	19.1	20.0	95.6
	> 30	2	4.3	4.4	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		

Table 3: Combined number of math content and pedagogical content courses taken by teachers

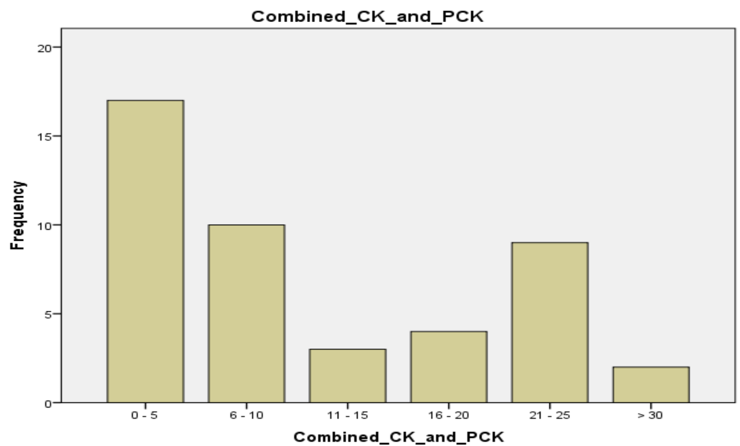


Figure 5: Bar chart showing combined number of math content and pedagogical content courses taken by teachers

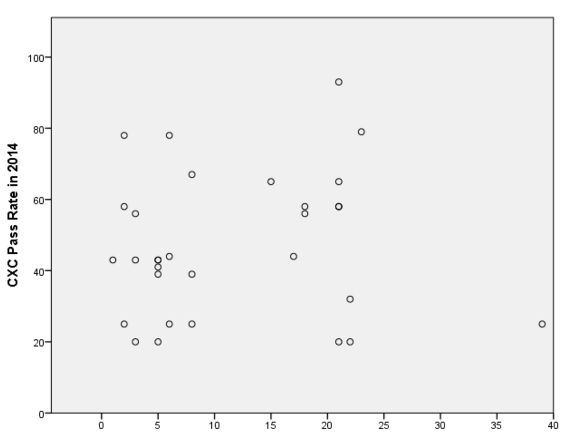


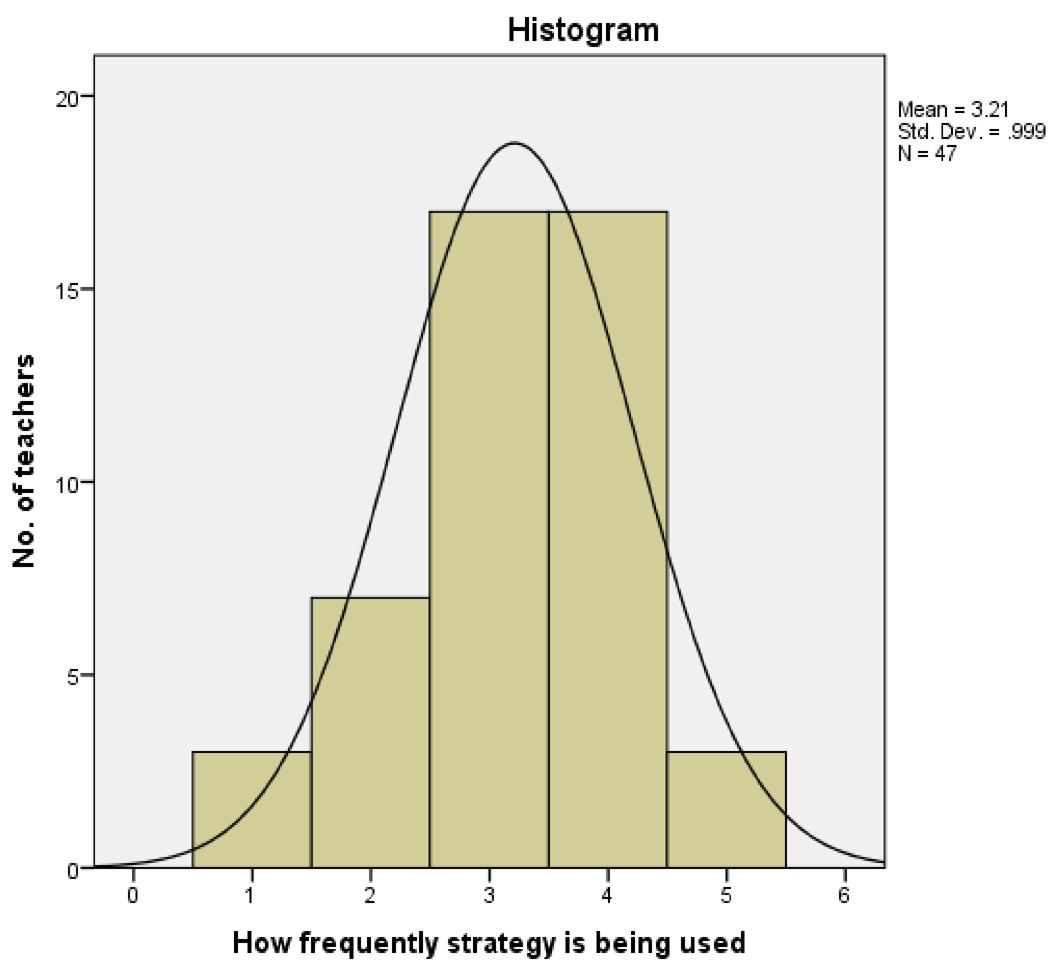
Figure 4: Scatterplot showing relation between students CXC performance and teachers' combined content and pedagogical content knowledge

Analysis of Dominica's 4th and 5th Form Mathematics Teachers Teaching Strategies

Exploration and Investigation

Table

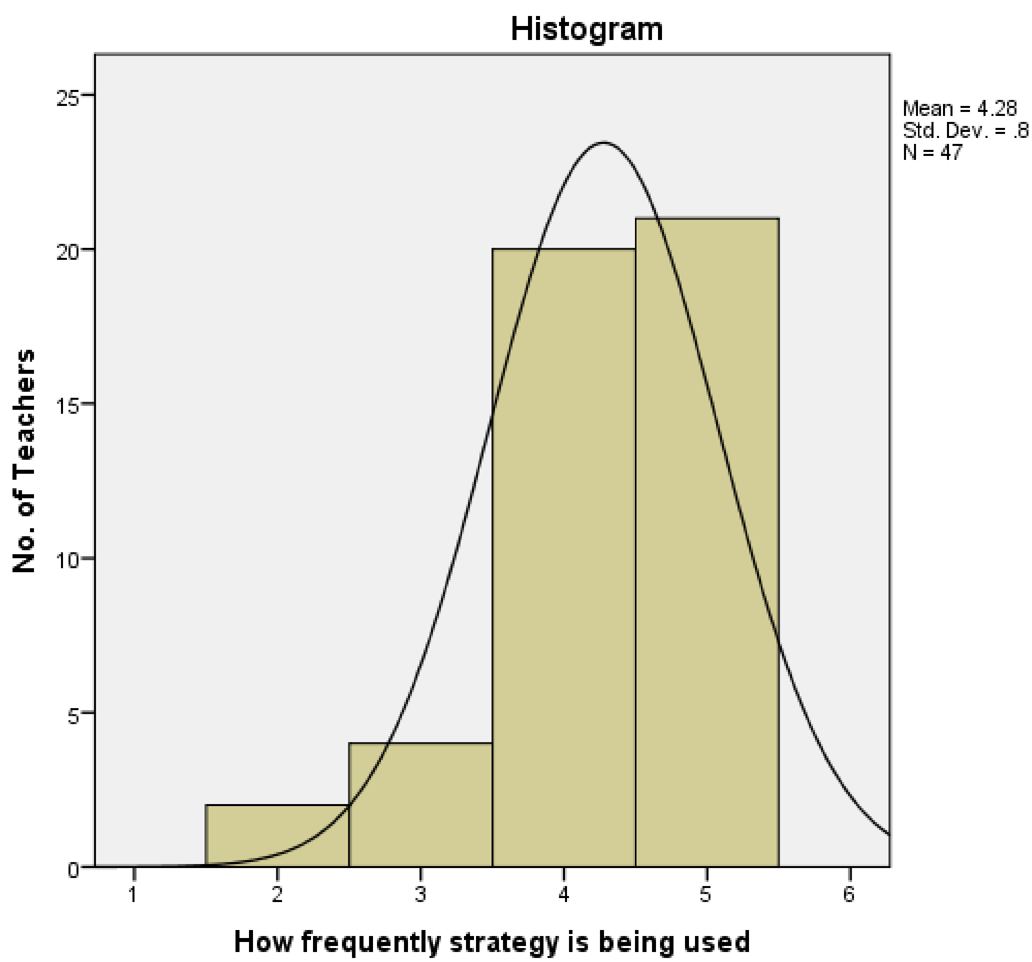
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	6.4	6.4	6.4
	2	7	14.9	14.9	21.3
	3	17	36.2	36.2	57.4
	4	17	36.2	36.2	93.6
	5	3	6.4	6.4	100.0
	Total	47	100.0	100.0	



Use Students Prior Knowledge

Table

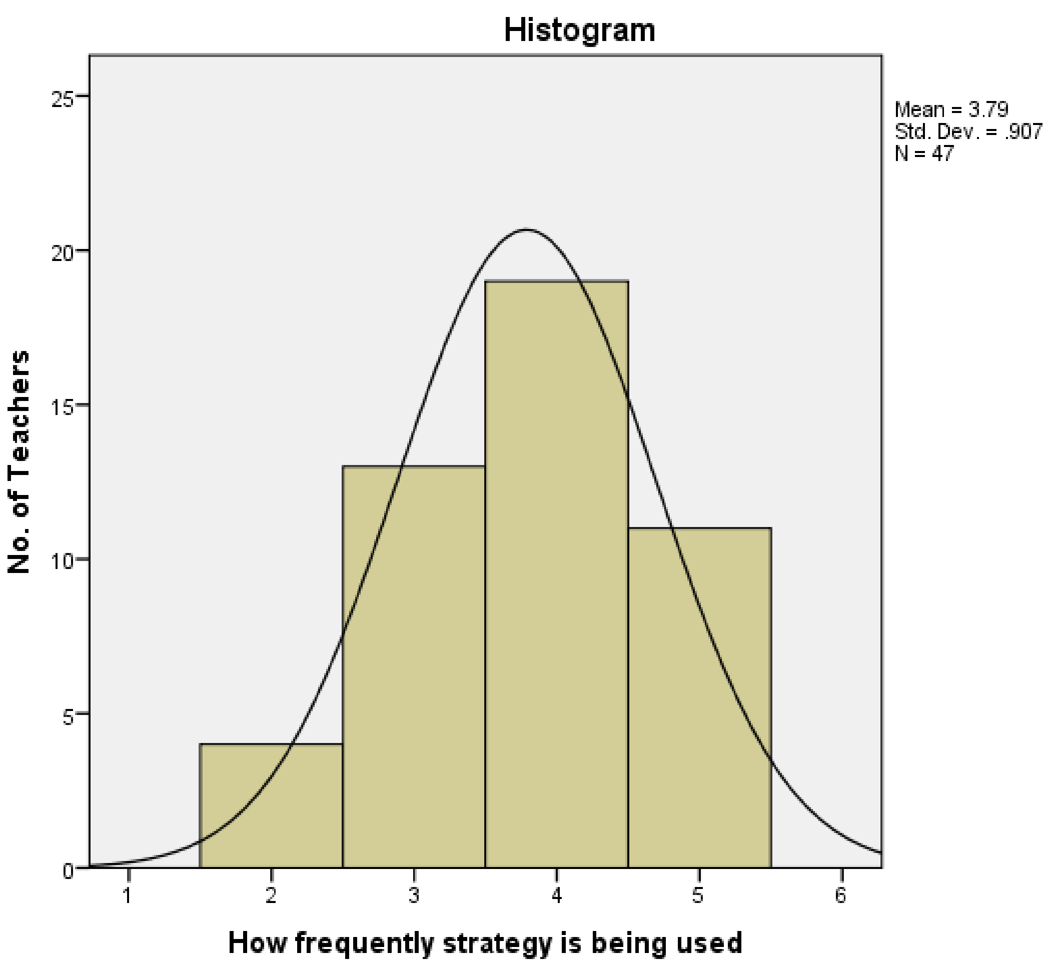
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	4.3	4.3	4.3
	3	4	8.5	8.5	12.8
	4	20	42.6	42.6	55.3
	5	21	44.7	44.7	100.0
	Total	47	100.0	100.0	



Use Manipulatives and visual aids

Table

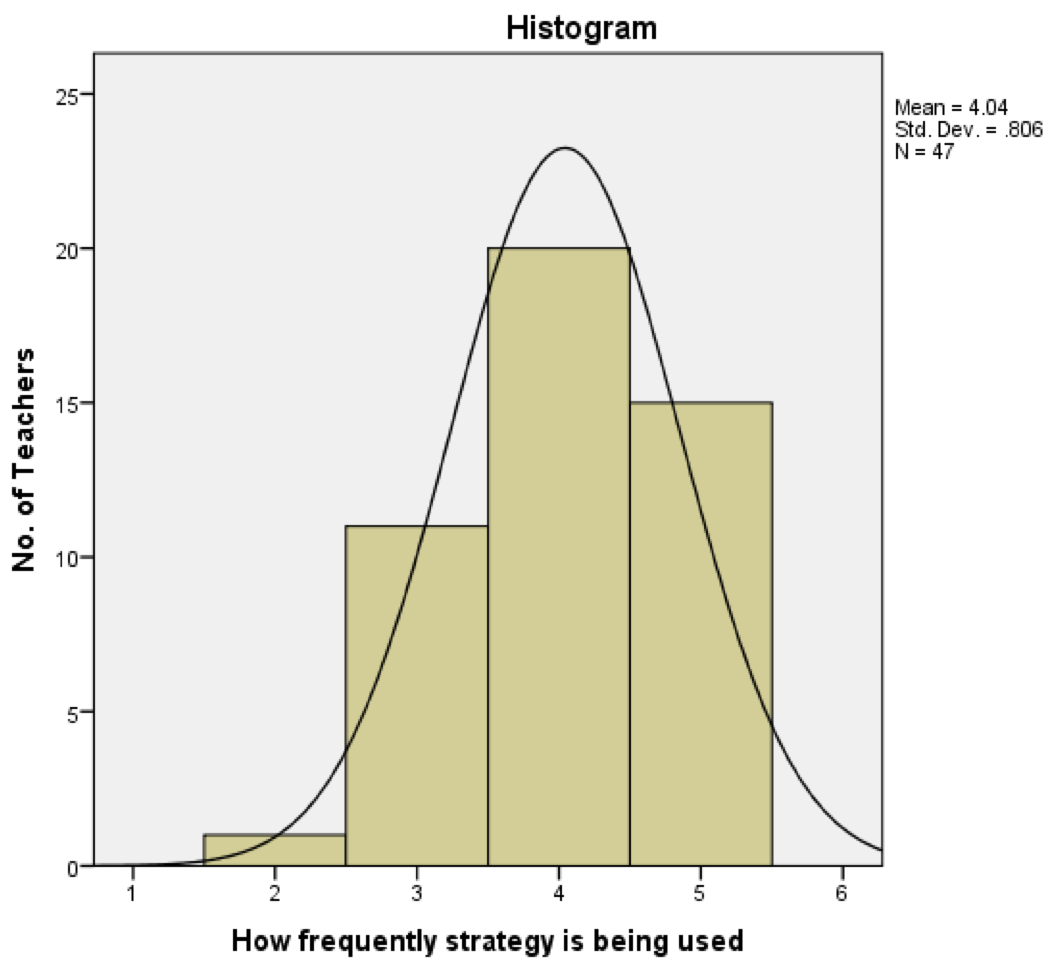
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	4	8.5	8.5	8.5
	3	13	27.7	27.7	36.2
	4	19	40.4	40.4	76.6
	5	11	23.4	23.4	100.0
	Total	47	100.0	100.0	



Use real world problem solving activities

Table

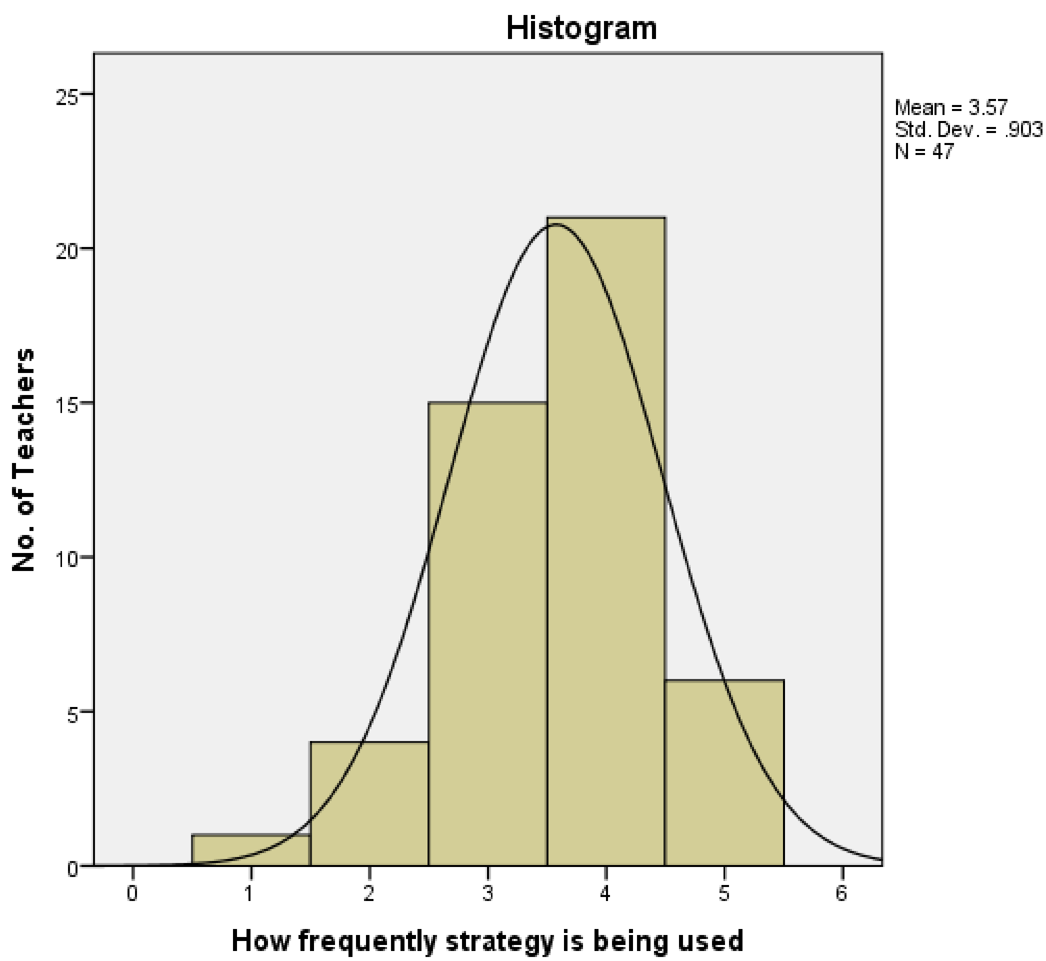
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	2.1	2.1	2.1
	3	11	23.4	23.4	25.5
	4	20	42.6	42.6	68.1
	5	15	31.9	31.9	100.0
	Total	47	100.0	100.0	



Integrate math with other content

Table

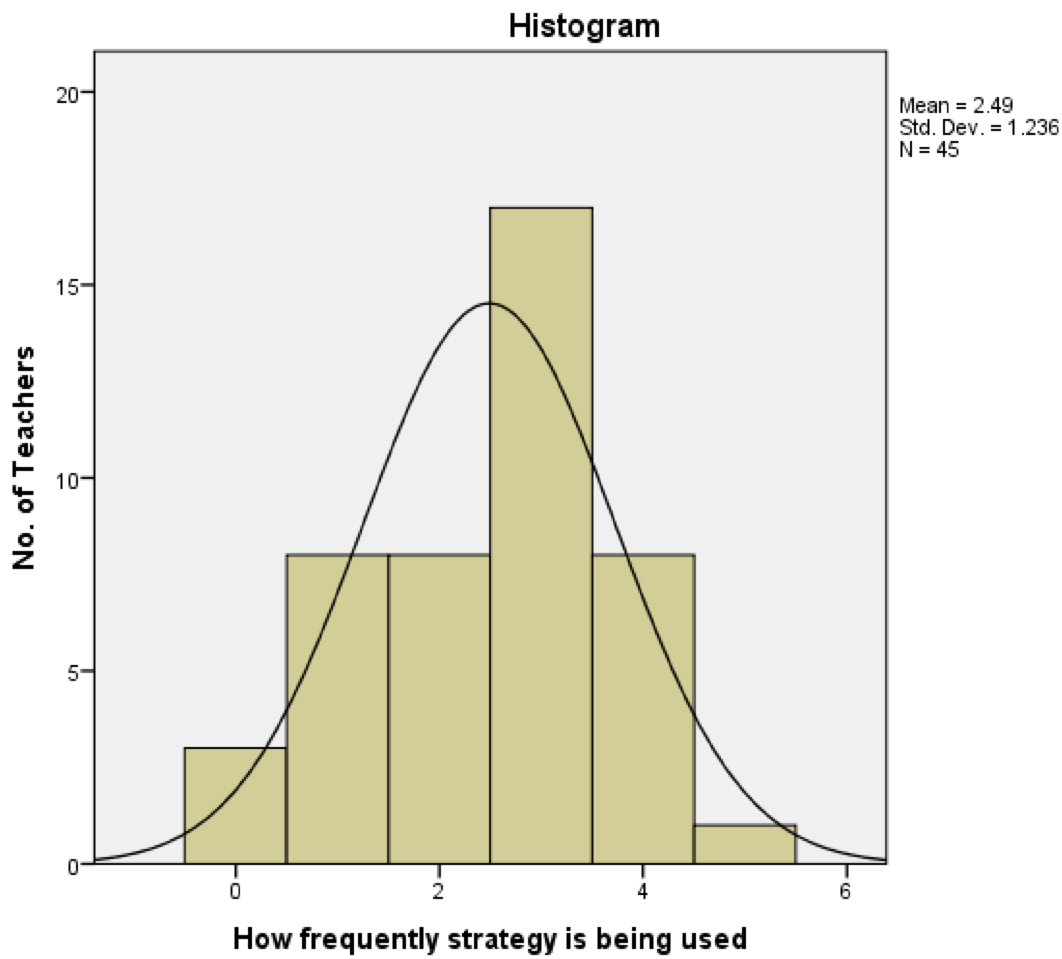
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.1	2.1
	2	4	8.5	8.5	10.6
	3	15	31.9	31.9	42.6
	4	21	44.7	44.7	87.2
	5	6	12.8	12.8	100.0
	Total	47	100.0	100.0	



Use Technology

Table

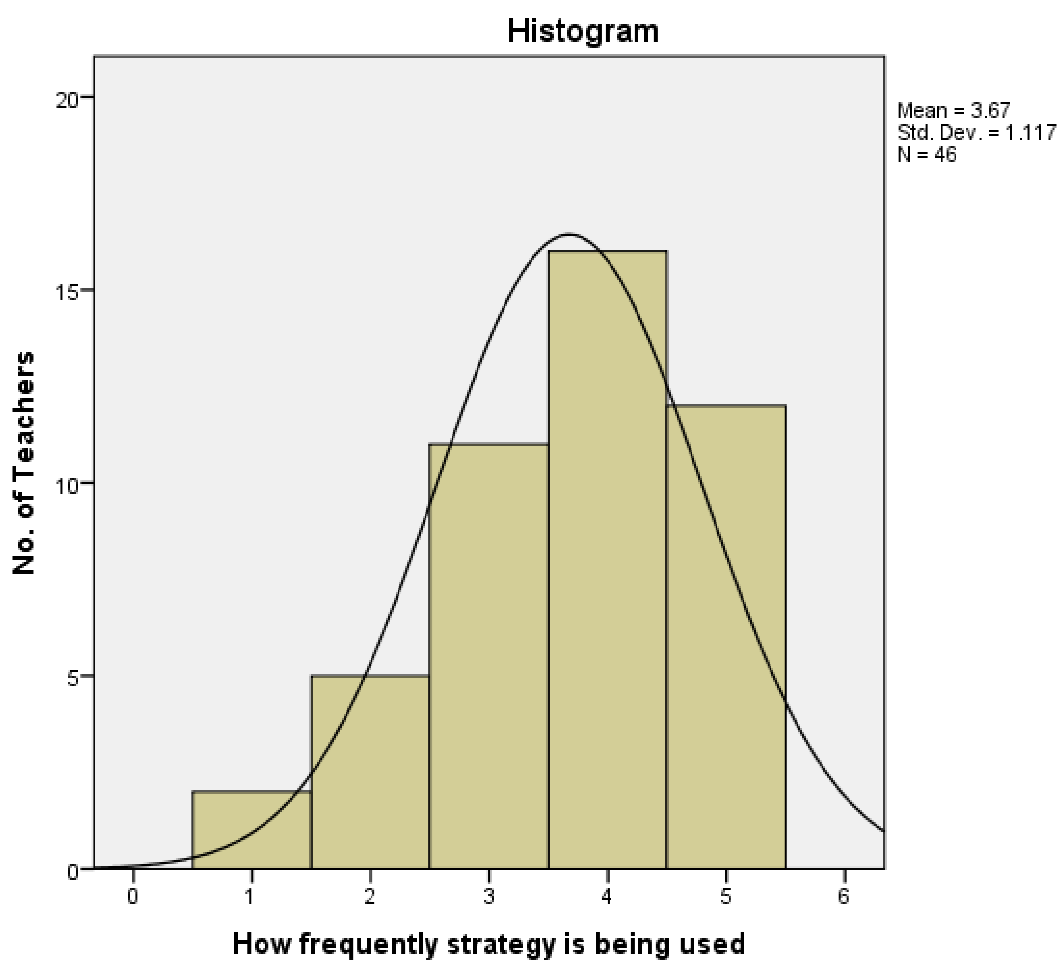
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	6.4	6.7	6.7
	1	8	17.0	17.8	24.4
	2	8	17.0	17.8	42.2
	3	17	36.2	37.8	80.0
	4	8	17.0	17.8	97.8
	5	1	2.1	2.2	100.0
	Total	45	95.7	100.0	
Missing	System	2	4.3		
Total		47	100.0		



Students use oral and written expressions

Table

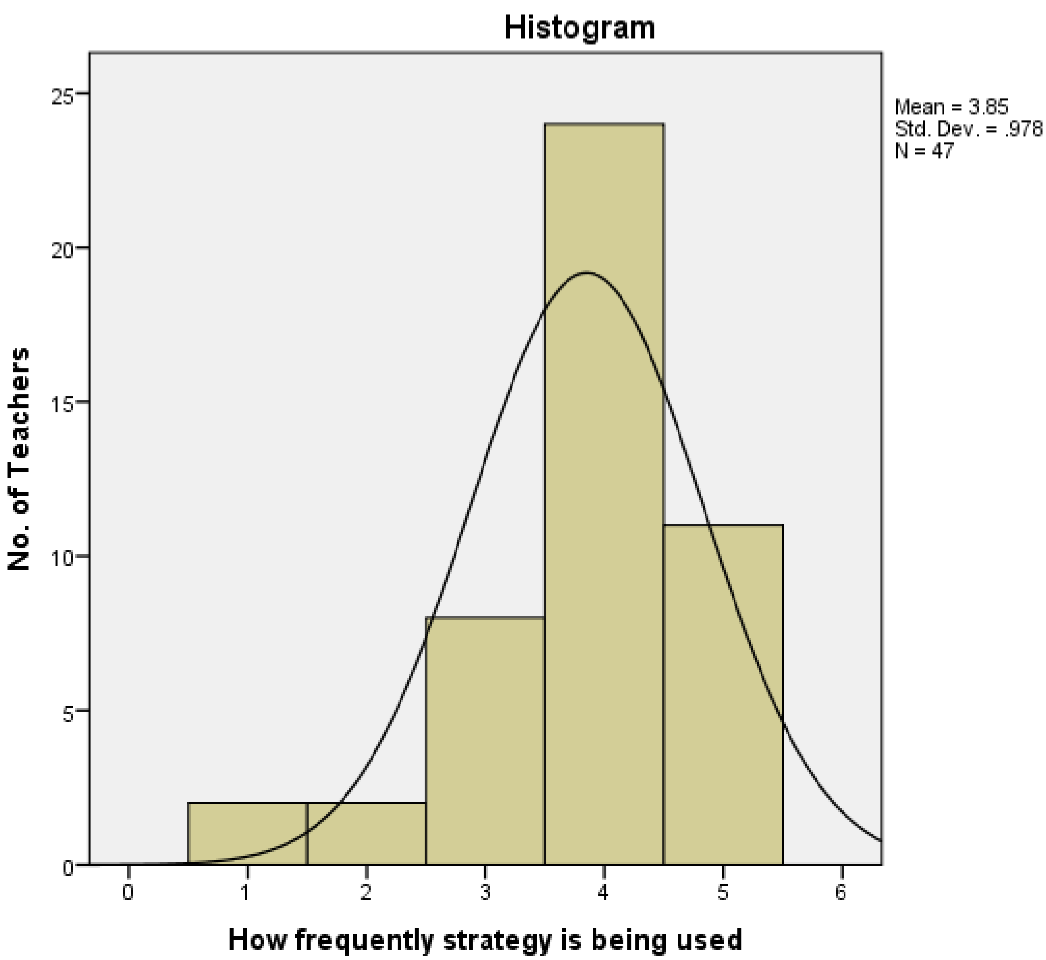
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	5	10.6	10.9	15.2
	3	11	23.4	23.9	39.1
	4	16	34.0	34.8	73.9
	5	12	25.5	26.1	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		



Encourage collaboration

Table

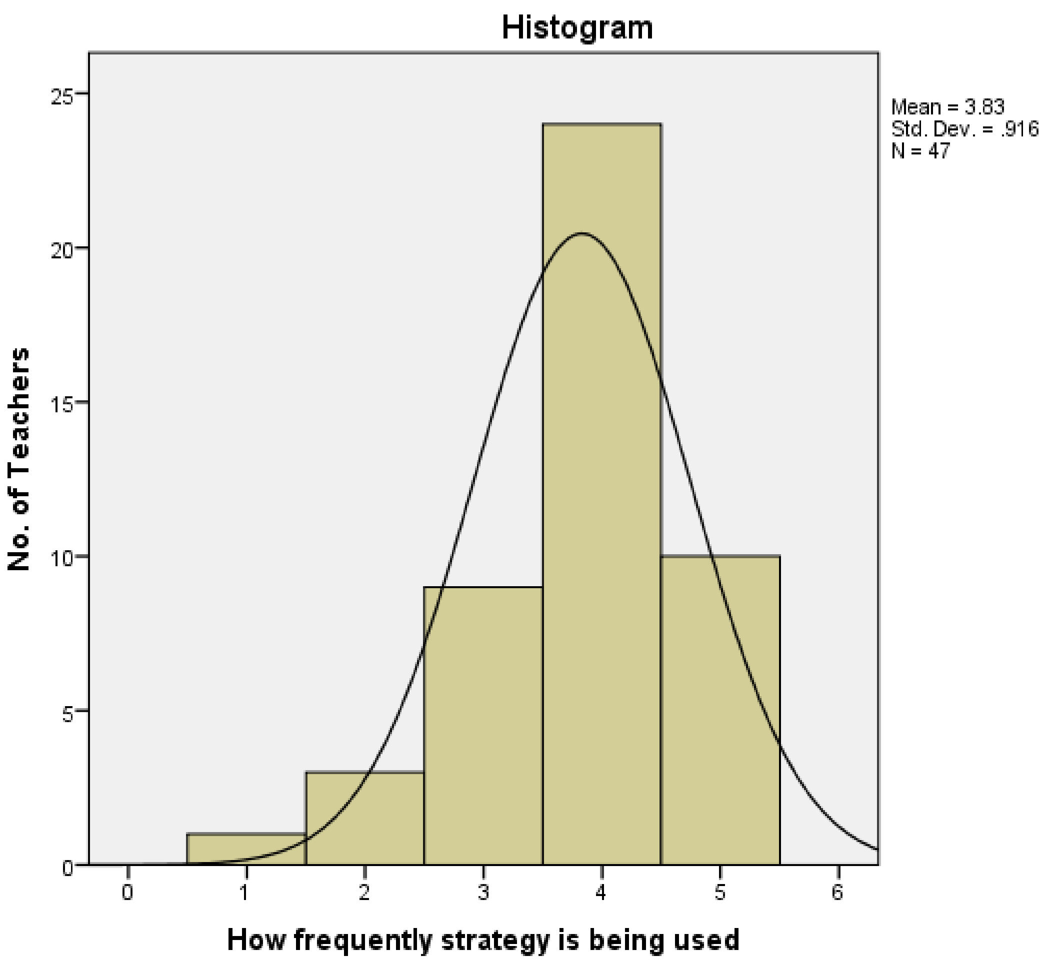
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	2	4.3	4.3	8.5
	3	8	17.0	17.0	25.5
	4	24	51.1	51.1	76.6
	5	11	23.4	23.4	100.0
	Total	47	100.0	100.0	



Use students errors

Tables

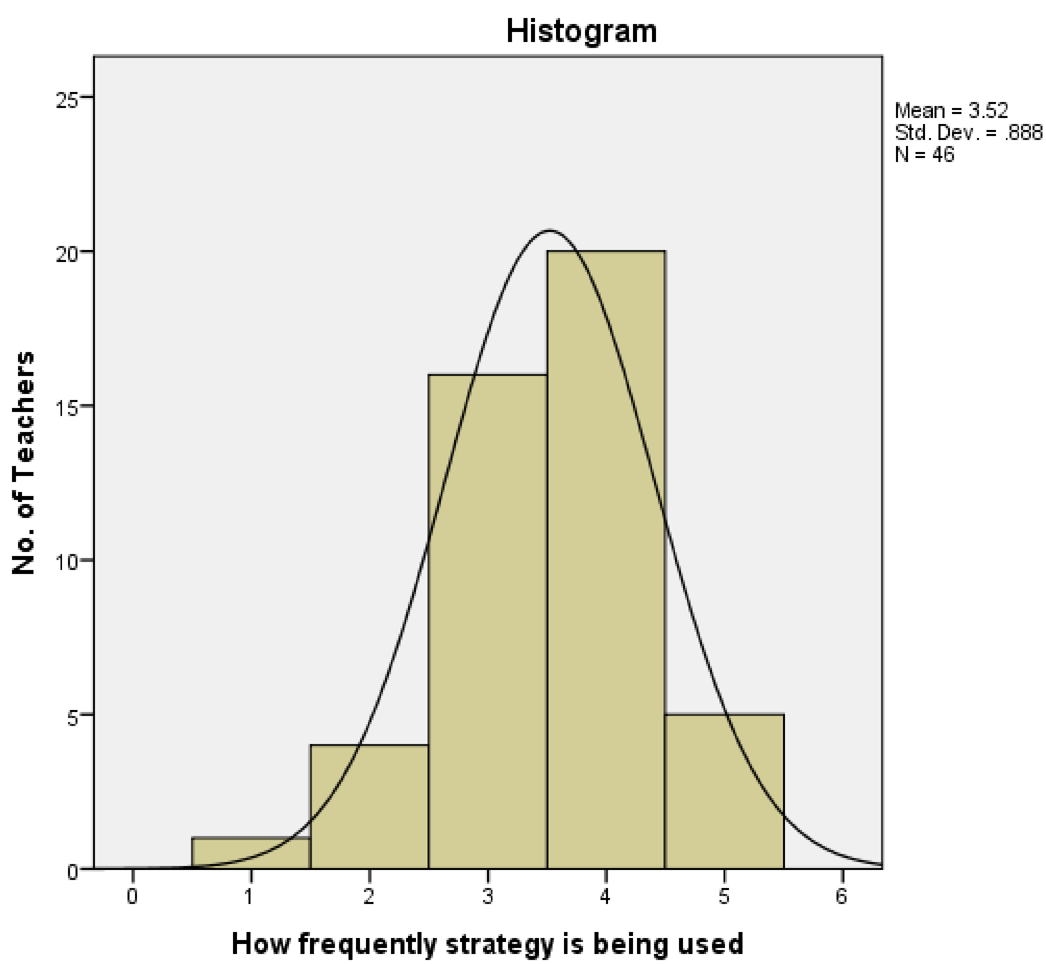
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.1	2.1
	2	3	6.4	6.4	8.5
	3	9	19.1	19.1	27.7
	4	24	51.1	51.1	78.7
	5	10	21.3	21.3	100.0
	Total	47	100.0	100.0	



Offer challenging activities to all students

Table

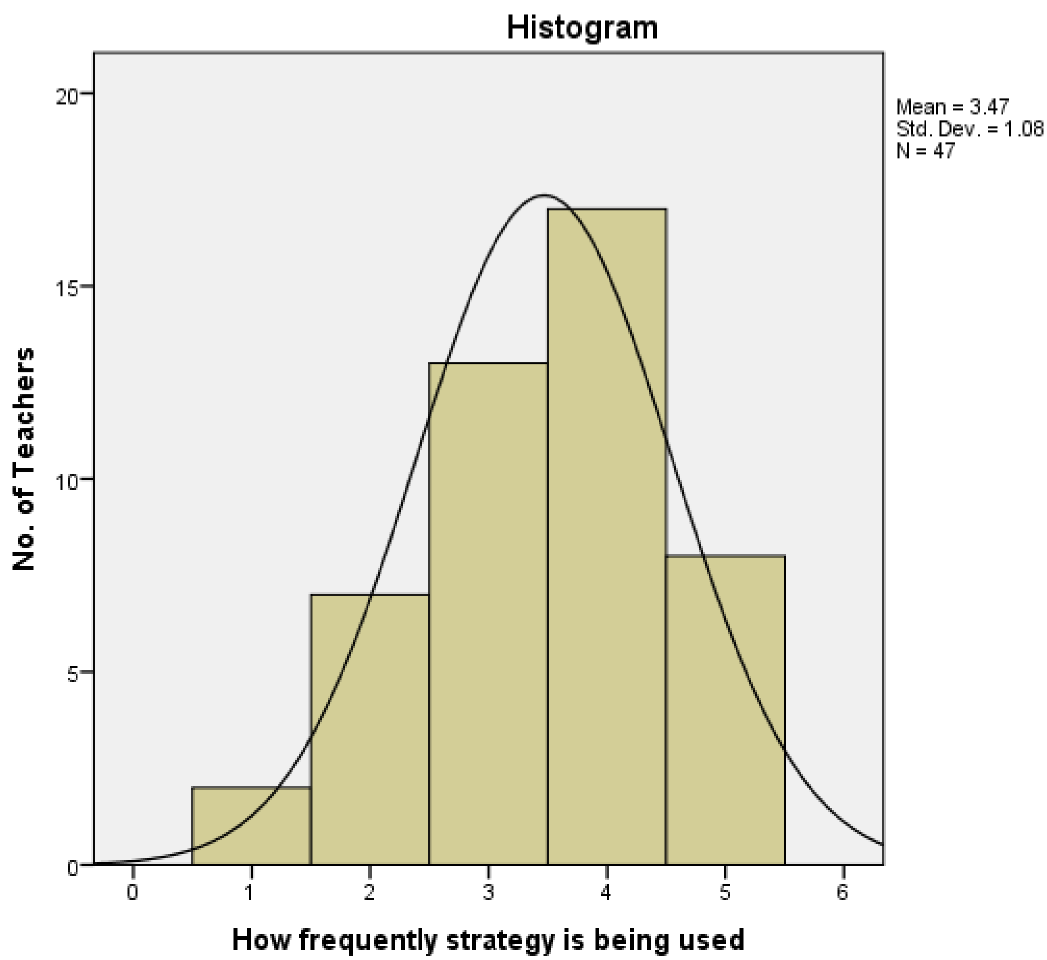
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.1	2.2	2.2
	2	4	8.5	8.7	10.9
	3	16	34.0	34.8	45.7
	4	20	42.6	43.5	89.1
	5	5	10.6	10.9	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		



Use a variety of problems

Table

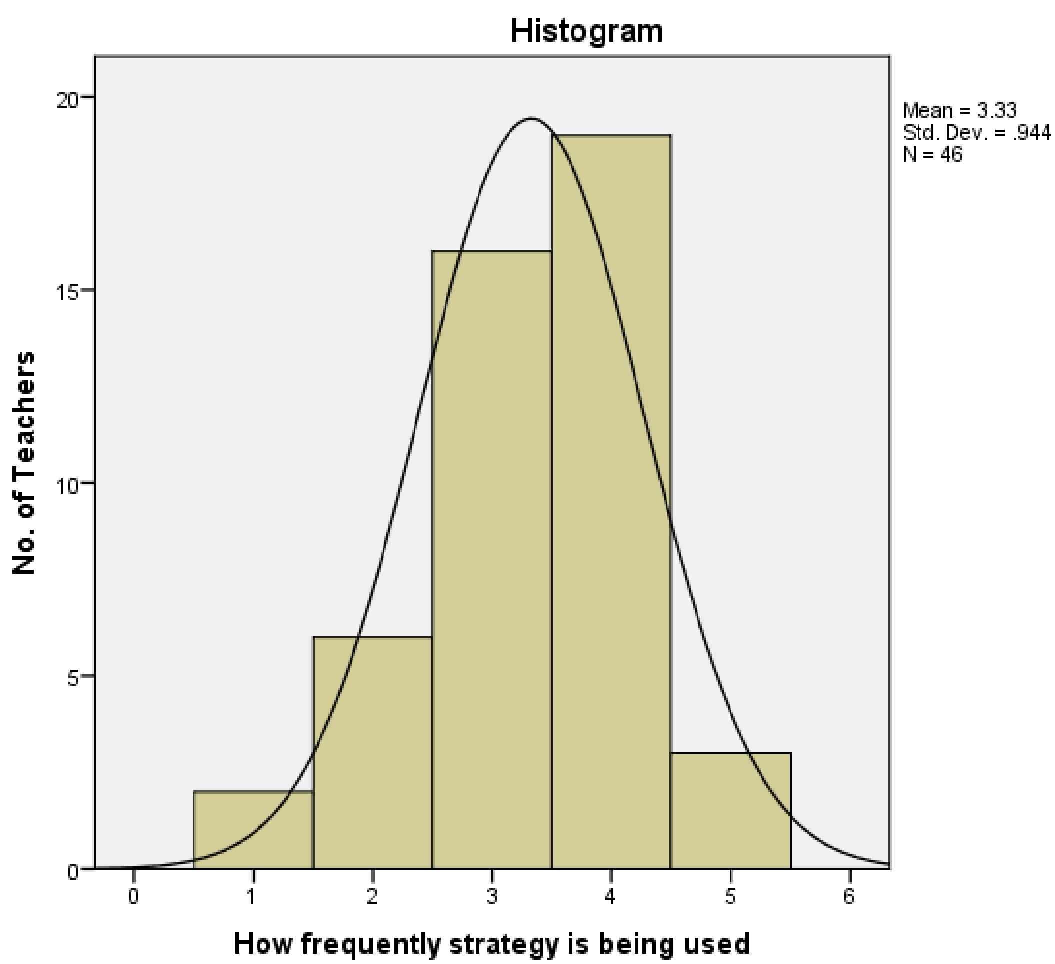
Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	7	14.9	14.9	19.1
	3	13	27.7	27.7	46.8
	4	17	36.2	36.2	83.0
	5	8	17.0	17.0	100.0
	Total	47	100.0	100.0	



Use relevant context

Table

Frequency of use		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.3	4.3	4.3
	2	6	12.8	13.0	17.4
	3	16	34.0	34.8	52.2
	4	19	40.4	41.3	93.5
	5	3	6.4	6.5	100.0
	Total	46	97.9	100.0	
Missing	System	1	2.1		
Total		47	100.0		



Analysis of Dominica's 4th and 5th Form Mathematics Teachers Beliefs about Mathematics

Statements	Number of Teachers					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No response
Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures.	17	22	2	3	0	3
Only the mathematics to be tested is important and worth knowing. For example, formulas are important, but their derivations are not.	0	4	3	21	18	1
It is important to adhere to the methods and strategies prescribed in textbooks.	1	12	11	14	6	3
The sequence: (a) gaining attention, (b) informing the learner of the objective, (c) stimulate recall, (d) present stimulus material, (e) provide learning guidance, (f) elicit the performance, (g) provide feedback, (h) assess performance, and (i) enhance retention and transfer; is the best approach to teaching mathematics.	8	16	17	3	1	2
Creating an educational environment that permit students to assume responsibility for their learning, building on students' existing knowledge base, extending students' repertoire of cognitive and metacognitive strategies, and correcting specific learning problems; is the best approach to teaching mathematics.	10	26	9	0	0	2
Real life application is the most important in teaching and learning mathematics.	9	23	13	1	0	1
Process is the most important in teaching and learning mathematics.	7	22	14	2	0	2
To teach mathematics, we need to explain concepts using concrete materials.	4	26	14	2	0	1
When introducing a new concept, we always need to use concrete objects.	4	17	15	10	0	1
I need to help children develop abstract knowledge from concrete examples by illustrating the concept using concrete models.	10	27	8	1	0	1
In mathematics teaching, conceptual understanding is very important.	20	24	1	1	0	1
In mathematics teaching, procedural knowledge is very important.	14	27	3	1	0	2
I feel my students learn mathematics well through my instructional methods.	10	28	5	1	0	3
All [normal] students, both male and female, can learn mathematics.	23	16	4	2	1	1