Teacher Qualification Characteristics and Secondary School Students' Mathematics Achievement: Convergent Parallel Mixed Methods

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Abstract
Many CSEC candidates are consistently underperforming at their Mathematics examination The Teacher Qualification Characteristics (TQCs) are linked to students' Mathematics achievement. The qualitative arm of this research utilized the grounded theory which generated a substantive theory, while the quantitative arm utilized the Spearman's rho correlation and the chi-square tests. These tests explored and explained the relationship and association between TQCs and students' achievement and how the TQCs were linked to students' 2016 CSEC Mathematics achievement in the British Virgin Islands. There were 33 respondents who participated in the semi-structured individual and focus group interviews, while the 2016 CSEC Mathematics ordinal grades from 105 students were tested along with the demographic information of their eight teachers. The results show that there was a statistically significant relationship and association between TQC (teacher qualification, teacher certification, and teacher Mathematics teaching experience) and students' ordinal grades. Finally, two data sets converged.

Keywords:
Certification, Coaching, Experience, Mathematics, Professional development, Teacher qualification

1. Introduction

Maximizing students' learning capacity in the Mathematics classrooms remains a growing concern for many educators (McLymont, 2000). The debate on mathematics education and the question of the Teacher Qualification Characteristics (TQCs) remain relevant. The TQCs and the way Mathematics is taught are likely to improve students' achievement in CSEC Mathematics. Improving students' mathematical achievement has been the most hotly debated topic in some learning institutions (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2008). These debates are centered on the best practices for preparing teachers to improve the outcomes for their students (Boyd et al., 2008). The ultimate aim of the education system is to equip teachers with the necessary Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) with the aim of improving students' mathematical achievements. The qualitative arm of this convergent parallel mixed methods research utilize the classical grounded theory which generated a substantive theory. On the other hand, the quantitative arm of the research incorporated the Spearman's Rho Correlation and the Chi-square analyses to show how TQCs are related to and associated with the 2016 CSEC Mathematics achievement grade in the British Virgin Islands (BVI). The independent data sets from both research designs were then merged to evaluate the nature of convergence (Creswell & Plano Clark, 2011). The researcher shift the emphasis from an isolated researcher perspective to an interactive one (Schechter, 2007). This was supported by Creswell (2009) who established that using either qualitative or quantitative design is inadequate for a comprehensive understanding of the phenomenon of interest.

1.1 Background of the Study

The 2006-2016 CSEC Mathematics examinations grades, across the Caribbean territory in general and students within the BVI in particular, showed that the BVI had been consistently performing at a higher standard than the rest of the Caribbean. Table 1 reflects this performance.

Table 1
Whole Territory and BVI Performance of CSEC Mathematics during 2006-2016

Year of Examination	No. of Registrants In the whole territory	No. of Registrants In the BVI	No. of Registrants obtaining Grades *I – III* In the whole territory	No. of Registrants obtaining Grades *I – III* In the BVI	% of Registrants obtaining Grades *I – III* In the whole territory	% of Registrants obtaining Grades *I – III* In the BVI
2006	86, 479	43	30, 267	43	35	100
2007	86, 835	79	29, 524	67	34	85
2008	77,000	74	30,490	59	42	80
2009	91, 370	92	37, 462	67	41	73
2010	88, 400	119	36, 244	78	41	66
2011	90, 000	123	31, 500	80	35	65
2012	95, 000	149	31, 350	90	33	60
2013	92, 400	194	27, 720	107	30	55
2014	90, 100	238	45, 050	162	50	68
2015	85, 042	265	48, 347	195	57	74
2016	92, 529	139	40, 712	122	44	88

Note. The table represents the aggregate performance of students in the CXC territories and the BVI in particular. The mean number of students who registered for the CSEC Mathematics examination, in the whole territory is 88 650.45 while the mean number in the BVI is 137.7. The mean number of registrants who obtained Grades *I – III* in the whole territory is 35 333.27 as against 97.27 in the BVI. In the whole territory, only once did the percentage of registrants securing Grades *I – III*, rose above 50, while for the same period in the BVI, the percentage of registrants who obtained Grades *I – III* were all above 50%.

The employment criteria for teachers of secondary schools in general but Mathematics teachers in particular, have been exemplary. Teachers within the BVI community are exposed to regular professional development sessions in their content area, sponsored by the Ministry of Education. In addition, Mathematics and Science teachers are given additional financial benefits, over their counterparts from other subject disciplines. As a result, the identification of the TQCs that statistically contribute to students' academic performance in Mathematics is worth studying. Identification and understanding the TQCs that may account for relatively high performance at the CSEC Mathematics examinations, in the BVI, may contribute to a significant difference in the rest of the Caribbean territory. To engineer a change in students' academic achievement across the CSEC territory, teachers need to have a shift in perspective and view Mathematics as a beautiful experience and not as something mechanic, difficult and boring (Chu-Carroll, 2009). The process of effective change starts with teachers who are competent coaches in Mathematics education, qualified, certified, have experience teaching secondary school Mathematics, and attend regular professional development sessions tailored to address the academic needs of students.

1.2 Statement of the Problem

Many CSEC Mathematics registrants are consistently underperforming at the Mathematics examination due to their inability to grasp basic mathematical concepts (Annual Technical Report, 2006-2016). There are some opinions about the probable cause, and indications in the literature about the causes of poor mathematical achievement, but the literature explored do not reveal any prior study that explored potential indicators of poor CSEC mathematical achievement in the wider Caribbean territory. Numerous recent studies have examined teacher qualification and students' Mathematics achievement (Woolridge, 2003; Keith, 2004; Gould, 2010; Stanford, 2014; Stewart, 2013) but it appears that no single study has comprehensively combined the five TQCs (a) teachers' qualification, (b) teachers' certification, (c) teacher's experience, (d) professional development, and (e) academic coaching, established in this research.

1.3 Purpose of the Study

The purpose of this convergent parallel mixed methods research, utilizing the grounded theory, Spearman's rho, and Chi-square approaches, was two fold: (a) the grounded theory approach was utilized to generate a substantive theory that explains how the five TQCs contributed to the 2016 CSEC Mathematics achievement in the British Virgin Islands and (b) the Spearman's rho correlation and Chi-square were utilized to examine the relationship and association, respectively between the five TQCs and students' Mathematics achievement at the same examination. The reason for collecting both qualitative and quantitative information was to determine where the two data sets converge.

1.4 Philosophical Assumption and Interpretive Framwork

Tsai, Chai, Wong, Hong, and Tan (2013) articulated that epistemology (philosophical assumption) deals with the nature and justification of knowledge, while Creswell (2013) posited that pragmatism (interpretive framework) focuses on the practical implications of research. In this research, focus was given to epistemology described as a field of inquiry (Smeyers, 2013) simultaneously valuing, pragmatism, as what works in both subjective and objective knowledge (Creswell & Plano Clarke, 2011).

2.0 Methodology

The convergent parallel mixed methodology is used when the researcher wants to perform two independent data collection and analyses procedures that are only merged during the interpretation stage (Creswell & Plano Clark, 2011). Caruth (2013) stated that the mixed methods research is the merging of both qualitative (Glaserian grounded theory) and quantitative (Spearman's rho, and Chi-square) designs in the same research that emerged as a result of the observed limitations of both designs. Abowitz and Toole (2010) posit that the mixed design balances the strengths and weaknesses of individual designs. The convergent parallel mixed methods design model is represented in figure 1 below.

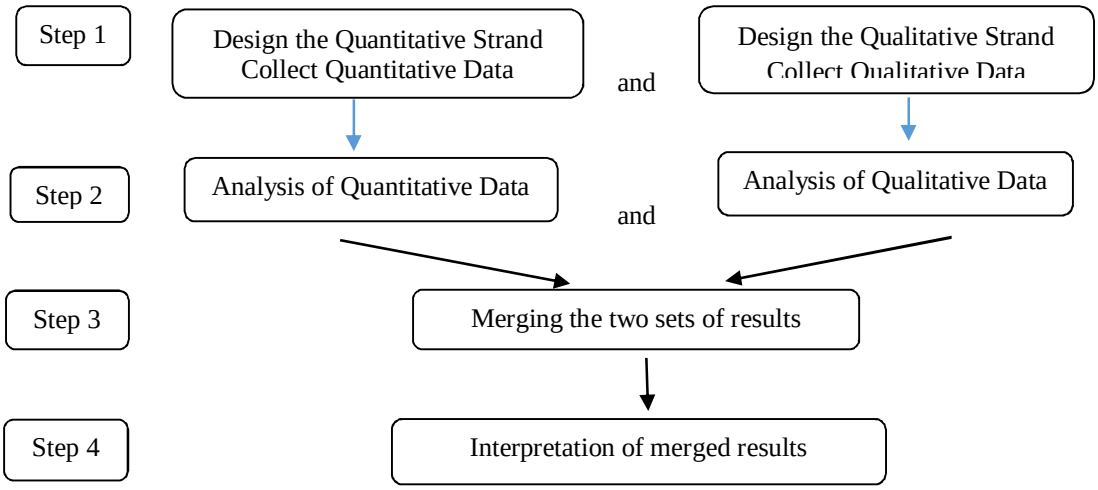

Figure 1. Flowchart for a Convergent Parallel Mixed Methods Research Design adapted from Creswell and Plano Clarke (2011).

2.1 Population, Sample, and Sampling Procedure

The population comprises of students from 19 CXC territories who sat the 2016 CSEC Mathematics examination. The average age range for students, is 15 – 19 years and the age range for teachers is 21 - 55. The sample size amounted to 113 students and their eight teachers. Of this total, 27 students and six teachers were purposively sampled for the grounded theory approach (qualitative arm). Creswell (2013) recommended that 20 to 30 persons be involved in a grounded theory design, to ensure the development of a well-saturated substantive theory. For the quantitative arm, Bastick and Matalon (2007) posit that a minimum of 30 participants can be used or the correlation and eight expected per cell for Chi-square. For the quantitative arm, the grades of 105 students and eight teachers were conveniently

selected. All of these respondents came from Elliot Princes High (EPH) and Georgian Moore Secondary (GMS) (Pseudonyms).

2.2 Data Collection Instruments/Sources and Procedure

The semi-structured, teachers' interview protocol, students' interview protocol, students' focused-group interview protocol, teacher's appraisal forms, and students' Mathematics copy books were instruments used to collect data. The ordinal grades students received at the 2016 CSEC Mathematics examination were also collected. These interviews captured the voices of the participants and therefore were used to develop a substantive theory grounded in the data collected. Each interview had three-rounds (Seidman, 2013). The first-round focused on the participants' historical experience interacting with Mathematics, prior to Grade 12. The second-round focused on the participants' ability to reconstruct their Grade 12 experience, and the third round focused on the participants' ability to reflect on the meaning of their Mathematics experience while in Grade 12. These interviews were held twice weekly, over six weeks, at an average duration of 70 minutes. This study was completed in 18 weeks with 14 research site visits. The "*Digital Voice Recorder, eBo Trade Portable Rechargeable 16GB USB Audio Dictaphone, MP3, FM Player*" was used to record all interviews.

2.3 Data Analysis Strategies

Onwuegbuzie, Johnson, and Collins (2009) contended that a true understanding of research can be made possible through the combination of quantitative and qualitative data. The qualitative and quantitative analyses were done separately and simultaneously Gay, Mills, and Airasian (2009) and then merged before the interpretation stage (Creswell & Plano Clarke, 2011). After listening repeatedly to the interview recordings the researcher made verbatim transcriptions. These transcribed notes were saved according to date, time, data source, data collection strategy, and research site. When the researcher was satisfied through member checks that the transcribed notes were what the participants conveyed, they were uploaded into QDA Miner 4.0 qualitative analysis software. The Statistical Package for the Social Sciences (SPSS) software (Joyner, Rouse, & Glatthorn, 2013) was used to analyze descriptive statistics, Spearman Rho correlation, and Chi-Square test of independence. The Bonferroni post hoc test in this research was used to adjust the p-value, when overall significance was found in the Chi-Square analysis. To conduct the post hoc test, the outcome in each cell was converted to a z-score and then to a new associated probability value, which was then compared with the adjusted Bonferroni alpha level. This adjustment determined the exact position of statistical significance.

2.4 Triangulation and Data Source Matrix

The data sources used to answer the research questions were placed in a triangulation matrix. This matrix is represented in Table 2 below.

Table 2

Research Questions and Methods of Answering in Triangulation Matrix

Research question	Ind. teacher interview	Ind. Student Interview	Stu. Focus Group	Documents.	Demo. Questionnaire	CSEC Math Results
Qualitative research question 1	√	√	√	√		
Qualitative research question 2	√	√	√			
Qualitative research question 3	√	√	√			
Qualitative research question 4	√	√	√	√		
Qualitative research question 5	√	√	√			
Quantitative research question 1 a					√	√
Quantitative research question 1 b					√	√
Quantitative research question 1 c					√	√
Quantitative research question 1 d					√	√
Quantitative research question 1 e					√	√
Quantitative research question 2 a					√	√
Quantitative research question 2 b					√	√
Quantitative research question 2 c					√	√

2.5 Legitimation in Mixed Methods Research

Onwuegbuzie and Johnson (2006) said that the use of the word validity in mixed methods research could be counterproductive and therefore a more acceptable alternative, is legitimation. Onwuegbuzie and Johnson (2006) identified nine concerns of legitimation of which five are directly related to this research:

(a) Sample integration legitimation: the participants must be involved in both qualitative and quantitative components of a study. In this research, the researcher utilized the 2016 CSEC Mathematics ordinal grades of 105 students and the demographic information of their eight teachers for the quantitative orientation, while 27 students and six teachers, from the same sample, were engaged for the qualitative orientation.

(b) Inside-outside legitimation: this involved combining inferences from the qualitative and quantitative arms of the study (Onwuegbuzie & Johnson, 2006). To justify this legitimation, there must be member checks of which the researcher conducted regularly.

(c) Weakness minimization legitimation: this suggests that the weaknesses from one approach is compensated by the strengths from the other approach. This research drew on the strengths of both approaches since the research process used the inferences that were made at the interpretation phase.

(d) Multiple validities legitimation: this is the extent to which all relevant validities are utilized (Onwuegbizie & Johnson, 2006). Hence, the seven validation strategies used in this research were: member checks, triangulation of data, maximum variation, peer reviews, pilot study, adequate engagement in data collection, and collecting detailed descriptive data.

(e) Paradigmatic mixing legitimation: is a means of utilizing two distinct approaches in a single study (Onwuegbuzie & Johnson, 2006). The two approaches in this research were merged before the interpretation of the data.

2.6 Transferability and Generalizability

Merriam (2009) purported that the most common generalization in qualitative research is a reader or user generalizability. Readers of this research may consider areas that may be applied to their specific situation. In addition, any generalization from the sample to the population, would have to be made with extreme caution due to the relatively small sample size.

2.7 Ethical and Legal Issues

Access and hierarchy, informed consent, and pseudonyms and anonymity encapsulate the ethical and legal issues. Access to students as respondents was possible through making contact with their parents. Seven parents gave permission for their child to be a part of the research. Respondents, as well as their research sites, were assigned pseudonyms for the sole purpose of withholding their identity. Table 3 below shows the composition of secondary schools in the BVI, according to school type and 2016 CSEC Mathematics registrants.

Table 3

BVI Candidates who sat 2016 CSEC Mathematics Examination

Schools Pseudonyms	Registered Students	Students Sat	Schools Pseudonyms	Registered Students	Students Sat
	Public			Private	
EPH	104	98	SAH	26	24
BH	1	0	GMS	15	15
CEC	0	0			
	105	98		41	39

3.0 Results

3.1 Numerical Codes Assigned to Categories and CSEC 2016 Ordinal Grades in the BVI

For this research, categories, for each independent variable, were identified and assigned numerical codes, before uploading into SPSS Version 22.0 for analysis. Table 4 below shows the numerical codes that were used in this research along with the ordinal grades respondents received.

Table 4
Numerical Codes of each TQC entered into SPSS for Analysis

Teachers' Qualification Characteristics		# of Teachers	Numerical Codes	Total		
College Major				Grade I	Grade II	Grade III
	In-Field	5	1	15	32	27
	Out-of-Field	3	2	20	8	3
Total				35	40	30
Professional Certification	Traditional	2	1	6	18	9
	Alternative	3	2	12	12	16
	Untrained	3	3	17	10	5
Total				35	40	30
Mathematics Experience	1-3 Years	2	1	3	9	14
	7-9 Years	4	2	21	14	8
	10+	2	3	11	17	8
Total				35	40	30
Professional Development	25 or Less	3	1	5	16	16
	26-50	3	2	22	16	1
	51 or More	2	3	8	8	13
Total				35	40	30
Academic Coaching	21-60	4	1	19	18	16
	61-100	3	2	13	19	8
	101 or More	1	3	3	3	6
Total				35	40	30

3.2 Spearman's Rho Correlation Analysis

The central quantitative research question #1: Is there a statistically significant relationship between teacher qualification characteristics (teacher qualification, teacher certification, teacher experience, professional development, academic coaching) and students' mathematical achievement grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination? Table 5 below presents the Spearman' rho correlation.

Table 5
Spearman's Rho Correlation between 2016 CSEC Mathematics Results and TQCs

	College Major	Professional Certification	Teacher Experience	Professional Development	Academic Coaching
CSEC Mathematics	.416	.235	.200	.116	-.052
Sig. (2-tailed)	< .001 *	.016 **	.041 **	.237 **	.599 **

Note. Sample size = 105

* Correlation is significant at the .001 level

** Correlation is significant at the .05 level

Research question 1a: Is there a statistically significant relationship between teachers' in-field and out-of-field majors in their academic preparation and students' final grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination? Table 5 above, revealed that there is a statistically significant positive relationship between teacher qualification (in-field and out-of-field majors) and students' ordinal grades [r=.416; p=.000 < α=.001]. The results showed that the null hypothesis was rejected at .001 alpha level. Hence, students with teachers who had Mathematics in-field majors received higher grades.

Research question 1b**:** Is there a statistically significant relationship between teachers' professional certification (traditional, alternative, or untrained) and the final grades (Grades *I, II, & III*) students received, as measured by the

2016 CSEC Mathematics May/June examination? Table 5 above shows that there is a statistically significant positive relationship between teacher professional certification and students' ordinal grades [r=.235; p=.016 < α=.05]. The results showed that the null hypothesis was rejected at 5% alpha level. Hence, students who are taught by teachers with traditional certification are likely to receive higher grades.

Research question 1c: Is there a statistically significant relationship between teachers' Mathematics teaching experience (1-3 years, 7-9 years, and 10+ years) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination? No teacher indicated, 4-6 years. Table 5 above revealed that there is a statistically significant positive relationship between teacher Mathematics teaching experience and students' ordinal grades [r=.20; p=.041 < α=.05]. The results state that the null hypothesis was rejected at 5% alpha level. Hence, students who were taught by teachers with 1-3 years of Mathematics teaching experience received higher grades than their counterparts who were taught by teachers with more years of teaching experience.

Research question 1d: Is there a statistically significant relationship between the total number of hours of teacher professional development sessions (at most 25 hours, 26-50 hours, greater than 50 hours) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination? Table 5 above revealed that the null hypothesis was retained [r=.116; p=.237 > α=.05]. Hence, no further analysis and interpretation was made.

Research question 1e: Is there a statistically significant relationship between academic coaching of students by their Mathematics teachers (at most 60 hours, 61-100 hours, and 101-140 hours) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination? Table 5 above shows that the null hypothesis was retained [r=-.052; p=.599 > α=.05]. Hence, no further analysis and interpretation was made.

The two TQCs that did not show statistical significance were not included in the chi-square analysis.

3.3 Chi-Square test of independence Analysis

The assumption of a non-normal distribution and the expected frequencies for any cell, were met.

Research question 2a: Is there a statistically significant association between teachers' in-field and out-of-field majors in their academic preparation and students' final grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination? Table 6 below shows the output of this data.

Table 6

Chi-Square Output table for Teacher Qualification

	2016 CSEC Results				Chi-Square Value	df	p-value
		Grade I	Grade II	Grade III	20.07	2	<.001
In-Field Major	Count	27	32	15			
	Expected Count	21.1	28.2	24.7			
	% of CSEC results	90	80	42.9			
	% of teachers qualification	36.5	43.2	20.3			
Out-of-Field Major	Count	3	8	20			
	Expected Count	8.9	11.8	10.3			
	% of CSEC results	10.0	20.0	57.1			
	% of teachers qualification	9.7	25.8	64.5			
Total	Count	30	40	35			
	% of CSEC results	100	100	100			

*Note.*0 cells (0.0%) have expected count less than 5.

The minimum expected count is 8.9

Hence, the null hypothesis was rejected [p=.000 < α =.001]. This suggest an overall statistically significant association between the teacher qualification (in-field and out-of-field) majors and students' achievement. Students who were taught by teachers with an in-field major performed better than students who were taught by teachers with an out-of-field major.

Research question 2b: Is there a statistically significant association between teachers' professional certification (traditional, alternative, or untrained) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination? Table 7 below shows the output table for teacher certification.

Table 7

The Chi-Square Output table for Teacher Certification

2016 CSEC Results					Chi-Square Value	df	p-value
		Grade I	Grade II	Grade III	13.318	4	.010
Untrained	Count	5	10	17			
	Expected Count	9.1	12.2	10.7			
	% of CSEC results	16.7	25.0	48.6			
	% of teachers certification	15.6	31.3	53.1			
Alternative	Count	16	12	12			
	Expected Count	11.4	15.2	13.3			
	% of CSEC results	53.3	30.0	34.3			
	% of teachers certification	40.0	30.0	30.0			
Traditional	Count	9	18	6			
	Expected Count	9.4	12.6	11.0			
	% of CSEC results	30.0	45.0	17.1			
	% of teachers certification	27.3	54.5	18.2			
Total	Count	30	40	35			
	% of CSEC results	100	100	100			

Note. 0 cells (0.0%) have expected count less than 5.
The minimum expected cell count is 9.1

Hence, the null hypothesis was rejected [p=.010< α =.05]. This suggests that, overall, there is a statistically significant association between teachers' professional certification (traditional, alternative, or untrained) and students' achievement. A Post Hoc Test with an adjusted Bonferroni alpha level was used to determine where the statistically significant association is identified. To conduct the Post Hoc Test, the outcome in each cell was converted to an adjusted z-score and then to a new associated probability value which was then compared with the adjusted Bonferroni alpha level. Table 8 below shows the summary of the corrected Bonferroni Post Hoc test.

Table 8

Bonferroni Adjustment and Teacher Certification Statistical Value

z-score value	Chi-square value	Adjusted α-value α/9 = .05/9 = .00555
2.8 > 1.96	7.84	p=.00511< α=.00555

This result revealed the Bonferroni adjustment for teacher certification. The statistical significance lay only between students who receive Grade III passes in Mathematics and teachers who are untrained.

*Research question 2c***:** Is there a statistically significant association between teachers' Mathematics teaching experience (1-3 years, 7-9 years, and 10+ years) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination? The output is shown in Table 9 below.

Table 9
The Chi-Square Output table for Teacher Experience

	2016 CSEC Results				Chi-Square Value	df	p-value
		Grade I	Grade II	Grade III	15.921	4	.003
1-3 Years	Count	14	9	3			
	Expected Count	7.4	9.9	8.7			
	% of CSEC results	46.7	22.5	8.6			
	% of teachers certification	53.8	34.6	11.5			
7-9 Years	Count	8	14	21			
	Expected Count	12.3	16.4	14.3			
	% of CSEC results	26.7	35.0	60.0			
	% of teachers certification	18.6	32.6	48.8			
10+ Years	Count	8	17	11			
	Expected Count	10.3	13.7	12.0			
	% of CSEC results	26.7	42.5	31.4			
	% of teachers certification	22.2	47.2	30.6			
Total	Count	30	40	35			
	% of CSEC results	100	100	100			

Note. 0 cells (0.0%) have expected count less than 5.
The minimum expected count is 7.4

The null hypothesis was rejected [$p=.003 < \alpha = .05$]. This suggests an overall statistically significant association between teachers' Mathematics teaching experience (1-3 years, 7-9 years, and 10+ years) and students' achievement. A Post Hoc test was used to determine where the statistically significant association lay. Table 10 below shows the summary of the corrected Bonferroni Post Hoc test.

Table 10
Bonferroni Adjustment and Mathematics Teaching Experience Statistical Value

z-score value	Chi-square value	Adjusted α-value $\alpha/9 = .05/9 = .00555$
3.3 > 1.96	10.89	$p=.00097 < \alpha=.00555$
2.8 > 1.96	7.84	$p=.00511 < \alpha=.00555$

The post hoc test results reveal that with the Bonferroni adjustment for teachers' Mathematics teaching experience, that the significance lay between students receiving Grade I passes in Mathematics and teachers with 1-3 years of experience. Also, significance lay between students receiving Grade III passes in Mathematics and teachers with 7-9 years of experience.

3.4 Generating Grounded Theory

Open coding started with the first piece of information that was collected. These open codes were derived as a result of a systematic analysis of teachers' individual interview, students' individual interview, students' focus group interview, and documents. There were 21 open codes and 13 initial categories. These codes have an accumulated frequency of 229 counts. After further consideration of the relationship between the initial categories and open codes, the researcher merged similar categories and codes using the merging feature within the QDA Miner 4.0 software. Strauss and Corbin (1990) posited that the process of merging concepts of a similar nature is called categorizing. Table 11 below shows the final list of categories and codes that were analyzed.

Table 11

Final List of Categories and Codes

Final Categories	Final Codes	Counts	Count %
Experience	Teaching for understanding	84	37
Academic Coaching	Improving students' mathematical performance	47	21
Professional development	Students and teachers benefit	40	17
Qualification	Extending knowledge	31	14
Certification	Teachers receiving professional training	24	11
Total		226	100

This analysis was instrumental in answering the research questions below.

Qualitative Research Question #1a: How did teachers' in-field and out-of-field Mathematics training contribute to Grade 12 students' academic achievement in Mathematics as measured by the 2016 CSEC Mathematics examination? Two themes emerged: (a) teachers' competence and content knowledge and (b) additional teacher professional qualification.

(a) *Teachers' competence and content knowledge:* Data from 13 participants revealed that teachers' competence and content knowledge dictate that they should have at least a Bachelor's degree (in-field) in Mathematics content knowledge to be competent to respond to students' questions adequately, fill the gaps in their knowledge, and prepare students well for the CSEC Mathematics examination.

(b) *Additional teacher professional qualification*: Data from five participants revealed that *a*additional teacher professional qualification (out-of-field) includes expertise in teaching strategies, which suggests that students can understand the mathematical concepts as a result of the teacher being a people person.

Qualitative Research Question #1b: How did the teachers' professional certification (traditional, alternative, or untrained) process contribute to Grade 12 students' academic achievement in Mathematics as measured by the 2016 CSEC Mathematics examination? Three themes were generated: (a) application and knowledge transfer, (b) equipping teachers with skills and techniques to address students' learning needs, and (c) developing skills in classroom management.

(a) *Application and knowledge transfer:* Data from five participants revealed that professional certification and training allow teachers to help their students to transfer their Mathematical knowledge and make applications to other situations.

(b) *Equipping teachers with skills and techniques to address students' learning needs*: Data from eight participants revealed that teachers' professional training equips teachers with skills to address students learning needs but is not necessarily a requirement for employment for the teaching of CSEC mathematics.

(c) *Developing skill in classroom management:* Data from six participants revealed that teacher certification programmes allow teachers to be flexible in the use of teaching strategies and to develop the skills to manage their classrooms.

Qualitative Research Question #1c: How did teachers' Mathematics teaching experience according to number of years (1-3 years, 7-9 years, and 10+ years) contribute to Grade 12 students' academic achievement in Mathematics as measured by the 2016 CSEC Mathematics examination? Three themes were generated: (a) effective teaching strategies,

(b) maximizing students Mathematics success through teacher mathematical experience, and (c) showing relevance between mathematical concepts and the real-world.

(a) Effective Teaching Strategies: Data from 16 participants revealed that students believe that regardless of their aptitude and learning differences, teachers should meet their learning needs through their teaching strategies.

(b) Maximizing students' mathematical success through teacher mathematical experience: Data from nine participants revealed that the more number of years of teaching experience a Mathematics teacher has, students are likely to perform better thus maximizing their success at the CSEC examination.

(c) *Showing relevance between mathematical concepts and the real-world:* Data from five participants revealed that in-depth teaching along with showing relevance between the mathematical concepts and the real-world experiences can help students to be successful.

Qualitative Research Question #1d: How did professional development sessions teachers attended, according to total number of hours (at most 25 hours, 26-50 hours, greater than 50 hours), contribute to Grade 12 students' academic achievement in Mathematics as measured by the 2016 CSEC Mathematics examination? Three themes were generated: (a) developing new teaching strategies through collaboration, (b) broadening the scope and focus on Mathematics content knowledge during professional development, and (c) professional development should be subject specific, relevant, and provide practical engagement.

(a) Developing new teaching strategies through collaboration: Data from eight participants revealed that collaboration between the school administration and Mathematics teachers in planning for professional development sessions is necessary to address teachers' and students' needs.

(b) Broadening the scope and focus on Mathematics content knowledge during professional development: Data from six participants revealed that broadening the scope and focus on professional development sessions can benefit students in their Mathematics classroom.

(c) Professional development should be subject specific, relevant, and provide practical engagement: Data from four partiicpants, all of whom are teachers, revealed that the benefits that professional development sessions offer are unlimited; therefore, they should be subject specific, relevant, and practical; catering for the needs of students and their teachers.

Qualitative Research Question #1e*:* How did academic coaching of students by their Mathematics teachers according to number of hours, (at most 60 hours, 61-100 hours, and 101-140 hours), contribute to Grade 12 students' academic achievement in Mathematics as measured by the 2016 CSEC Mathematics? examination? Six themes were generated: (a) addressing students' specific issues through academic coaching, (b) positive attitude of students and teachers enhance understanding, (c) preparing students for life, (d) communicate for understanding, (e) Mathematics made simple, and (f) Mathematics is fun.

(a) *Addressing students specific issues through academic coaching*: Data from seven participants revealed that academic coaching helps students and teachers to recognize their need for help and motivates them towards accomplishing their life-long goals.

(b) *Positive attitudes of students and teachers enhance understanding*: Data from four participants revealed that academic coaching leads students to a better understanding of challenging mathematical concepts and also helps teachers to understand students understanding and misunderstanding.

(c) *Preparing students for life*: Data from three participants revealed that academic coaching sessions help students to improve their mathematical achievement through the teaching of life-skills.

(d) *Communicate for understanding*: Data from five participants revealed that reading for a Bachelors' degree (in-field) is important but even more important is the teachers' ability to communicate the mathematical concepts effectively for students to understand.

(e) Mathematics made simple: Data from five participants revealed that teachers must be able to simplify or break-down the mathematical concepts for the students to understand.

(f) *Mathematics is fun:* Data from four participants revealed that students learn best in an environment that is conducive to learning.

3.5 Grounded Theory Identified

After a careful and systematic analysis, *Mathematical Mastery Maximization (3M)* was determined as the substantive grounded theory. Mathematical Mastery Maximization is not vacuous; it hinges on five TQCs. This theory also suggests that teachers and students must engage in effective communication especially during academic coaching sessions. However, this understanding is facilitated or curtailed by one's attitude towards the learning process (professional development). A (teacher's experience) at the CSEC Mathematics level is likely to improve their time management skills since adequately preparing students for examination is crucial. Figure 2 below demonstrates the relationship between categories and the core categories which led to the generation of the theory.

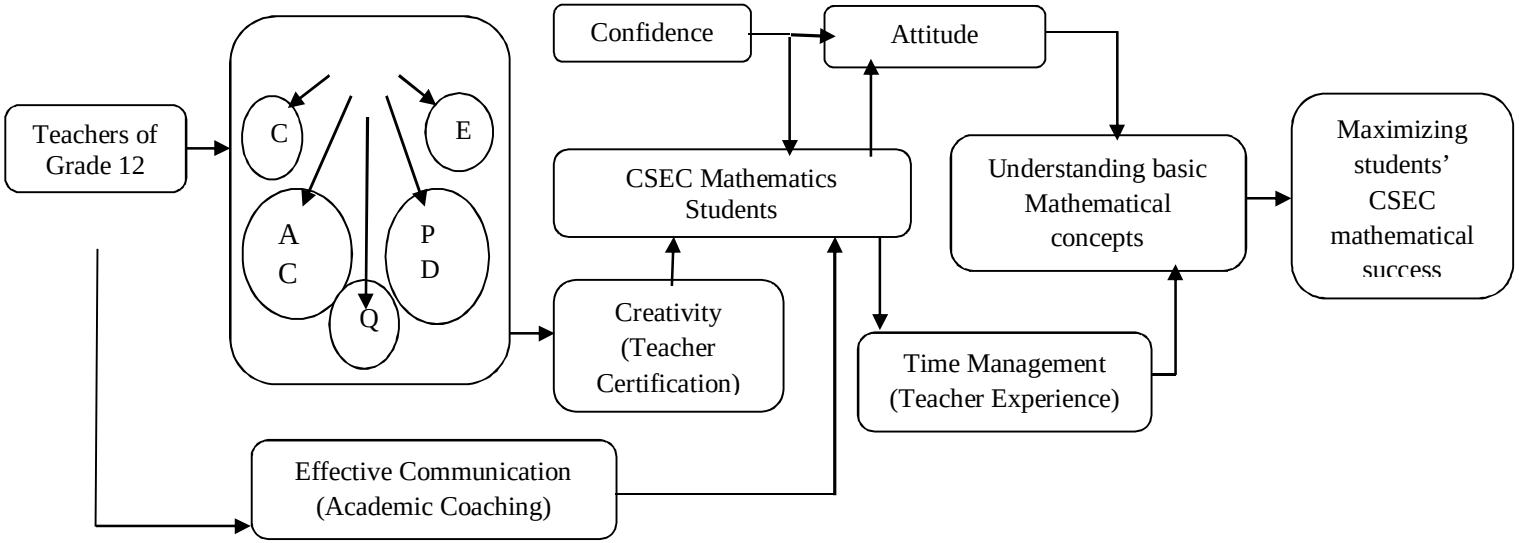

Figure 2. Networking Relationship between Categories and the Core Categories

3.6 Convergence of Quantitative and Qualitative Results

Three TQCs were merged from the qualitative and quantitative data sets: teacher qualification, teachers' professional certification, and teachers' Mathematics teaching experience. However, only two converged: teacher qualification and teachers' professional certification. This convergence is shown in figure 3 below.

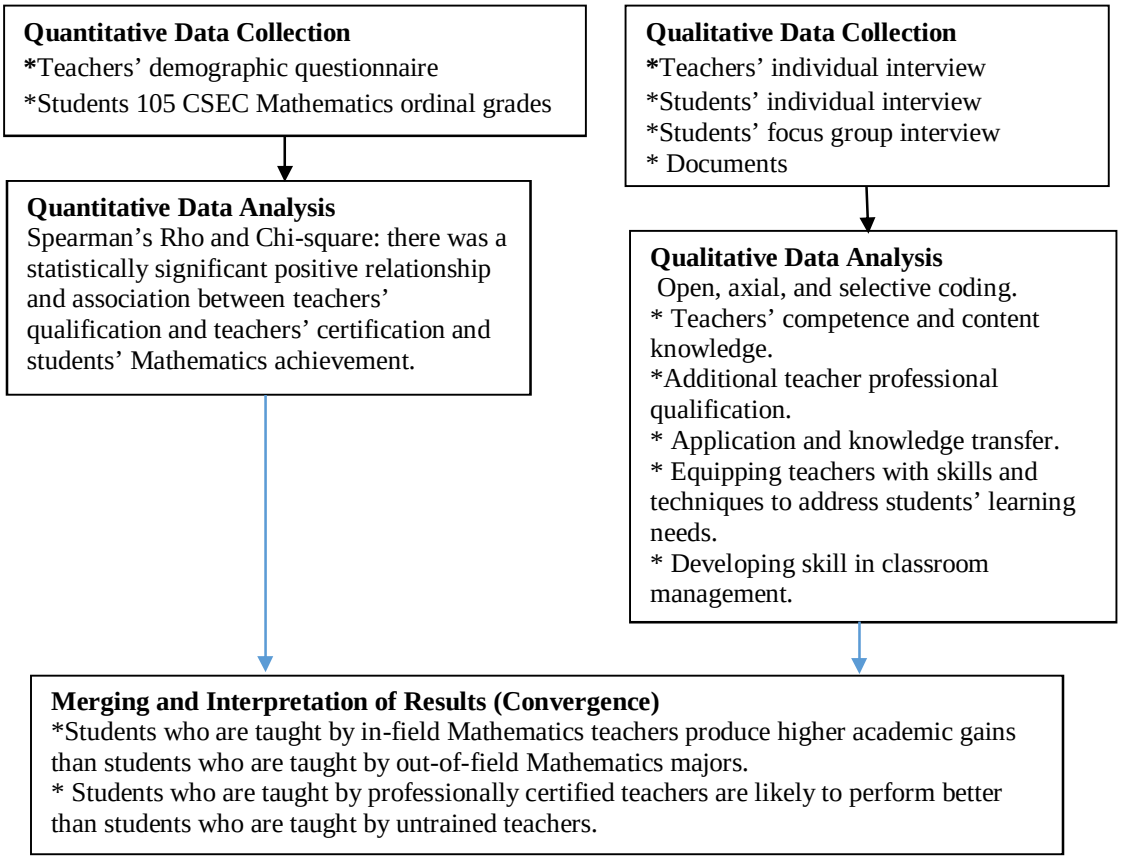

Figure 3. Convergence of two TQCs and Students' Mathematics Achievement

3.7 Merged findings – Teacher Qualification

In support, 27 students (90%) who earned Grade 1 passes were taught by teachers who have an in-field major while three students (10%) who gained Grade I were taught by out-of-field Mathematics majors. In addition, 32 students (80%) who earned Grade II passes, were taught by in-field Mathematics majors, while out-of-field Mathematics majors taught eight students (20%). Similarly, 15 students (42.9%) who obtained Grade III passes were taught by in-field Mathematics majors, while out-of-field majors taught 20 students (57.1%). Hence, students' success at the CSEC Mathematics level is contingent on teachers' academic qualification (in-field). Of the 105 students who received acceptable grades, 74 students (approximately 70%) was taught by in-field majors, and 31 students (approximately 30%) was taught by out-of-field majors. Hence, the qualitative and quantitative findings are convergent.

3.8 Merged findings – Teachers Professional Certification:

Untrained teachers taught 32 students (approximately 30%) who received acceptable grades. Forty students (approximately 38%) were taught by alternatively trained teachers, while traditionally trained teachers taught 33 students (approximately 31%) who earned acceptable grades. Students who were taught by professionally certified Mathematics teachers are likely to produce higher academic gains than students who are taught by untrained Mathematics teachers. Hence, the findings converged.

4. Discussion

4.1 Discussion of Merged Findings

Teacher qualification: The findings revealed that students who have teachers with an in-field Mathematics major are likely to outperform students who are taught by teachers who have an out-of-field Mathematics major. The finding of this research was supported by Morton, Peltola, Hurwitz, Orlofsky, and Strizek (2008) who said that students whose teachers held Mathematics majors have higher Grade 12 test scores in Mathematics. Goe and Sticker (2008) reported that teachers' qualifications are consistently associated with increase students' achievement in Mathematics. Goe and Sticker (2008) further revealed that high school students' who are taught by teachers having credentials of an *in-field* certification in Mathematics usually have higher grades. Finally, the U.S. Department of Education (2002) concurred that research has generally shown that high school Mathematics and science *in-field* teachers elicit greater gains from their students than *out-of-field* teachers when controlling for students' prior academic achievement and socioeconomic status.

Teacher certification. The findings revealed that while teacher certification is necessary, it is not essential for students' success at the CSEC Mathematics level. Teacher certification was viewed as a tool for flexibility in teaching strategy rather than a contribution to students' academic gains in CSEC Mathematics. It was surprising that statistical significance was found between students who received Grade 1 passes and untrained teachers. Being uncertified does not suggest incompetence. These findings are supported by Matagi-Tofiga (2011) whose research found a statistical significant relationship between teacher certification and students' achievement in Mathematics. Also, Darling-Hammond (2000) indicated that teacher certification has been strongly correlated with students' achievement in reading and Mathematics. Goe and Sticker (2008) supported by postulating that the differences in knowledge and skills of certified and non-certified teachers are not pronounced enough to be picked up in students' achievement. Students who were taught by alternatively trained teachers recorded the highest past rate, but this was not found to be statistically significant. Blazer (2012) concluded that alternatively certified teachers could produce students' achievement gains comparable to teachers who have been traditionally certified.

5. Conclusion

There were 105 students and their eight Mathematics teachers who participated in this research. Of this number, 33 (27 students and 6 teachers) participated in the qualitative arm. Spearman's rho correlation first tested for statistically significant relationship between the variables. The Chi-Square test of independence was then used to test for statistically significant association between the variables that had statistical relationship. These results must be interpreted with extreme caution since the sample size was relatively small (N=105). The data sets for teacher qualification and teacher certification converged.

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