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Original Paper

Teacher Qualification Characteristics and Secondary School Students' Mathematics Achievement: A Quantitative Study

Troy T. Brown, Ph.D[1] & Enid F. McLymont, Ph.D[1]

[1] Department of Graduate Education and Leadership, Northern Caribbean University, Mandeville, Jamaica

[*] Troy T. Brown, Ph.D, Department of Graduate Education and Leadership, Northern Caribbean University, Mandeville, Jamaica

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Abstract

Many Grade 12 Caribbean Secondary Education Certificate (CSEC) Mathematics examination registrants are consistently underperforming due to their inability to grasp basic mathematical concepts (Caribbean Examinations Council, 2006-2016). The purpose of this research was to examine the relation and association between five Teacher Qualification Characteristics (TQCs) and students' 2016 CSEC Mathematics achievement at two secondary schools in the British Virgin Islands (BVI). A sample size of 113 participants were incorporated in this research (N=105 students and N=8 teachers). These teachers taught these students CSEC Mathematics during the year of examination, 2015-2016. The Spearman's rho correlation revealed that there was a statistically significant positive relationship between teacher qualification, teacher certification, and teacher Mathematics teaching experience and students' ordinal grades at [r=.416; p=.000 < α=.001], [r=.235; p=.016 < α=.05], and [r=.20; p=.041 < α=.05] respectively. Similarly, the chi-square output showed a statistically significant association between teacher qualification, teacher certification, and teacher Mathematics teaching experience and students' ordinal grades at [p=.000 < α =.001], [p=.010< α =.05], and [p=.003< α =.05] respectively. On two occasions, the Bonferroni adjustment was used. For both tests, professional development and academic coaching were not statistically significant.

Keywords

Coaching, Mathematics, professional development, teacher certification, teacher experience, teacher qualification

1. Introduction

Teacher qualification characteristics and students' academic achievement in Mathematics have been a growing concern for many researchers, since Mathematics is seen as a core subject and some students are finding it difficult to grasp the basic mathematical concepts. The ever widening gap, between students' mathematical achievement and teachers' qualification characteristics, seems to be expanding exponentially. This discourse must be intentionally engaged since students' Mathematics achievement remains an educational concern. The way Mathematics is taught in the 21st Century classroom remains relevant, and teachers' participation in this discourse cannot be overstated. With such collaboration between teachers and students, students' performances are likely to improve. Teacher's experience in teaching Mathematics is likely to maximize students' learning potential (Brown, 2018). Our global education system is on the competitive edge and the way Grade 12 Mathematics is taught and learned, is perceived to account for differences in students' achievement.

Not only is Mathematics taught at every level within an educational institution (Yurniwati & Hanum, 2017) but it is taught as a core subject on every continent, yet students find its content challenging to grasp. This challenge is highlighted in the Caribbean Examination Council (CXC) annual technical reports (2006-2016). A review of these reports has inspired educators, from across the Caribbean region, to engage themselves in collaborative discussions and research geared towards improving students' mathematical achievement. The education system should ensure that teachers are equipped with the winning Teacher Qualification Characteristics (TQCs) that are perceived to make a significant difference in Grade 12 students' mathematical experiences.

The aim of this non-parametric quantitative research design was to provide an explanation of the relationship and association between five TQCs and Grade 12 students' 2016 CSEC Mathematics achievement, by using Chi-square analysis and Spearman's Rho Correlation. This research contributes to the current educational discourse since students are under-performing at their CSEC Mathematics examination (Caribbean Examination Council, 2006-2016). To meet these challenges, teachers are expected to undertake a greater responsibility that would contribute positively to students' academic gains and simultaneously reduce the achievement gap.

1.1 Background to the Study

This research has been influenced by the consistent level of Grade 12 CSEC Mathematics candidates within the BVI and the urgent need to reduce the performance gap in the wider Caribbean region. The summary of the annual technical reports for the CSEC Mathematics, May/June examinations, on students' performance within the CXC territories is shown in Table 1 below. This table specifically focuses on students' achieving acceptable grades (Grades *I* – *III*) only from within the Caribbean region.

Table 1. Performance in CSEC Mathematics Examination during 2006-2016, in the Caribbean Region

Year of Examination	No. of Registrants who sat the General Proficiency	No. of Registrants obtaining Grades *I-III*	% of Registrants obtaining Grades *I-III*
2006	86, 479	30, 267	35
2007	86, 835	29, 524	34
2008	T&T 20, 000	9, 400	47
	RoR 57, 000	21, 090	37
2009	91, 370	37, 462	41
2010	88, 400	36, 244	41
2011	90, 000	31, 500	35
2012	95, 000	31, 350	33
2013	92, 400	27, 720	30
2014	90, 100	45, 050	50
2015	85, 042	48, 347	57
2016	92, 529	40, 712	44

Note. T&T represents Trinidad and Tobago; RoR represents Rest of Region. The total for T&T and RoR was used in this analysis for 2008. The tally represents the aggregate performance of students in the CXC territories. The mean number of students who registered for the CSEC Mathematics examination, May/June sitting = 88 650.45. The mean % registrants obtaining Grades *I* - *III* = 35 333.27 (40), Range = 20 627, and Standard deviation ≈ 34.75.

This table shows that even though there have been an increasing number of registrants for the CSEC Mathematics examination, the percentage of candidates who received acceptable grades (Grades *I-III)* remained an educational concern. In 2015, the percentage of students who gained Grades *I-III* was the highest for the 2006-2016 period, at 57%. However, in 2016, there was a 13% decline from the previous year.

The article, "*Educators counting on new Math strategy*" (The Observer Online, 2011, October 26) used the example of Singapore education system to identify the changes that are needed for improved student learning. This article posited that students from the elementary level must be exposed to model manipulation and problem-solving skills. Bercovici (2014) stated that the falling scores in American students' achievement in Mathematics had prompted renewed interest in elementary Mathematics instruction. Yurniwati and Hanum (2017) said that to improve students' mathematical achievement at the secondary level there must be a change in Mathematics instruction from the expository to discovery teaching strategy, at the elementary level. Mediocre academic achievement scores should not continue within the Caribbean region or elsewhere and therefore students' improvement in their academic achievement in secondary school Mathematics, was examined closely through the lens of the TQCs. Table 2 below reflects the performance of candidates in CSEC Mathematics Examinations during 2006-2016, within the BVI.

Table 2. BVI Performance in CSEC Mathematics Examination during 2006-2016

Year of Examination	No. of Registrants who sat the General Proficiency	No. of Registrants obtaining Grades *I-III*	% of Registrants obtaining Grades *I-III*
2006	43	43	100
2007	79	67	85
2008	74	59	80
2009	92	67	73
2010	119	78	66
2011	123	80	65
2012	149	90	60
2013	194	107	55
2014	238	162	68
2015	265	195	74
2016	139	122	88

Note. The mean number of registrants who sat the CSEC examination = 137.7, while the mean number of registrants who obtain Grades *I – III* is 97 with a standard deviation = 4.47. Mean % registrants obtaining Grades *I - III* = 74 and Range = 152.

Comparing the performance of students during the 2006-2016 CSEC Mathematics examinations, across the Caribbean region in general and students within the BVI in particular, showed that the BVI registrants have been consistently performing at a higher standard. It is the general practice within the BVI that only students who show the proclivity to receive an acceptable grade (Grades *I, II, & III*) are allowed to sit the examination. The Mathematics teachers select their students to write the CSEC examination.

The requirement for teaching Mathematics does not automatically include attaining Mathematics certification. Some teachers may be qualified and trained in other subject majors but are still allowed to teach Mathematics, because of faculty shortage within the Mathematics department. These teachers within the BVI are exposed to regular professional development sessions sponsored by the Ministry of Education and Culture, in their content area and general classroom management skills. Within the local schools, teachers are encouraged to seek continuous development in their content major. For this reason, identifying the TQCs that explain students' mathematical achievement remains indispensable.

The TQCs that may account for such a relatively consistent high level of performance at the CSEC

Mathematics examinations, in the BVI, may contribute to a significant difference in the rest of the Caribbean region. For these reasons, this research is critical in the history of the Caribbean and can be the catalyst for positive changes, despite the thought that the schools can do more for their students.

Since the Coleman's 1966 report that schools' input makes little difference in students' learning, not much has been done to close this elusive gap in students' achievement. Johnson (2018) posits that to improve students' achievement, teachers must not look at the gap from a distance, but climb into it instead. In other words, teachers must become learners and interact more with the students under their care to understand plausable reasons for their underperformance. In addition, Dhanpaul (as cited in Chabrol, 2017) said, that Mathematics is a core subject for students in the Caribbean and they are finding it increasingly difficult to grasp basic concepts. Misunderstanding mathematical concepts magnify the challenges that Mathematics students and teachers are continuing to experience at the CSEC level. Hence, Mathematics educators should engineer change by assisting students in their understanding of basic mathematical concepts (Jamaica Gleaner, 2008, June 04).

To engineer a positive change in students' academic achievement, teachers need to expose learners to hands-on experiences (Musau & Abere, 2015). The process of effective change starts with the 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 teachers and students.

1.2 Statement of the Problem

Many Grade 12 CSEC Mathematics registrants are consistently underperforming at the CSEC Mathematics examination due to their inability to grasp basic mathematical concepts (Caribbean Examinations Council, 2006-2016). There are some indications in the literature about the probable causes of poor mathematical achievement, but the literature explored does not reveal any study that existed prior to this one that explored potential indicators of poor CSEC mathematical achievement in the Caribbean region. Recent studies have examined teacher qualification and students' Mathematics achievement (Gould, 2010; Stanford, 2014; Stewart, 2013), but it appears that no single study has comprehensively combined the five TQCs established in this research.

1.3 Purpose of the Study

The purpose of this non-parametric quantitative design was to determine the relationship and association between five teacher qualification characterisitics (teachers' qualification, teachers' certification, teachers' experience, professional development, and academic coaching) and Grade 12 students' ordinal grades as measured by the 2016 CSEC Mathematics examination, for 113 participants (105 students and 8 teachers) at two research sites in the BVI. The independent variables (teachers' qualification, teachers' certification, teachers' experience, professional development, and academic coaching), will be defined as school-based observable teacher qualification characteristics. The dependent variable (2016 CSEC Mathematics ordinal grade) will be defined as the official grades students received from CXC as evidence of their standard of performance.

2. Methodology

This research is a non-experimental design utilizing the Spearman's rho correlation and the chi-square statistical techniques. These two techniques are the most appropriate since they are able to explain the relationship and association, respectively, between the variables.

2.1 Non-Parametric Tests

The Spearman's rho analysis procedure was vital since it gave the researcher an idea of the magnitude and direction of the relationship between the TQCs and students' academic achievement as measured by the 2016 CSEC Mathematics examination. One of the more commonly used non-parametric statistical tests of significance for frequency counts is the chi-square (χ^2) test of independence. Chi-square is a measure of how statistically significant is the difference between observed frequency counts and expected frequency counts among participants in the data collected. Bastick and Matalon (2007) suggested that when using this test of independence, observations must be grouped into mutually exclusive categories. This suggests that the data must be dichotomous.

2.2 Population and Sample

This research focused primarily on the academic achievement of Grade 12 students as measured by the 2016 CSEC Mathematics examination. Students from 19 CXC territories are engaged in CSEC Mathematics examinations annually. However, only the BVI territory was involved in this research. On average, the age range of these students is 15-19 years.

There are five secondary schools in the BVI. The pseudonyms of these five schools are: Elliot Prince High (EPH), Georgian Moore Secondary (GMS), Breanna High (BH), Claudette Educational Center (CEC), and Seventh Avenue High (SAH). Of these five schools, only four registered their students to participate in the 2016 CSEC Mathematics examination. Of these four schools, only students from three schools actually sat the examination. The school the researcher teaches was included in these three schools, but it was excluded from the actual research. Hence, for this research, students' 2016 CSEC Mathematics ordinal grades from two secondary schools, EPH and GMS, were requested from the Ministry of Education and Culture, for analysis.

The sampling strategy used for this research was the convenience sampling strategy. Gay, Mills, and Airasian (2009) said that convenience sampling could be done when researchers are studying existing groups. Bastick and Matalon (2007) called these existing groups, intact groups. Seven teachers came from EPH and one came from GMS. Hence, the actual sample size for this research was 113 (105 students and 8 teachers). This sample size is relatively small and the multi-level nature of the data, limited the statistical analysis options.

2.3 Data Collection Instruments

This research was conducted for 18 weeks beginning on July 13, 2017, and concluding on November 16, 2017. The data collection instruments, used in this research, were the teachers' demographic questionnaire and the ordinal grades students received at the 2016 CSEC Mathematics examination. Creswell and Plano Clarke (2011) suggested that the researcher can collect quantitative data using instruments that measure individual performances and that these instruments can be created by the researcher, or by other researchers and used in their original form, or modified. The researcher created a teacher demographic questionnaire and matched the results from the 2016 CSEC Mathematics examination with the respective teacher. The demographic questionnaire for teachers asked for their responses to 11 statements. Collectively, the statements requested that teachers identify a suitable pseudonym to be used in the research as well as their age range. Critical to the teachers' demographic questionnaire was teachers' responses to statements about the five TQCs which are the independent variables for this research.

2.4 Quantitative Data Collection Procedure

The collection procedure followed was:

1. The researcher formally requested the ordinal grades of students' overall 2016 CSEC Mathematics results from the Chief Education Officer (CEO) (acting) within the Ministry of Education and Culture. The names of these students were never requested.

2. The CEO (acting) acknowledged receipt of the request and the researcher subsequently received a list of students' ordinal grades, by school/research site.

3. The researcher visited each school and engaged the vice principal, with respect to the verification of the results. The vice principal also gave a list of the teachers who taught each group of students. A second verification by the subject teacher was made for his/her group.

4. These ordinal grades were suitably organized into a computerizable format (Berg, 2009), by the researcher for the SPSS version 22.0 computer software to recognize.

5. Only information perceived to adequately explain the phenomenon of interest and aligned with testing the hypotheses were included.

6. This information was saved on an 8 GB Kingston flash drive and a Seagate External USB 2 TB device, according to date, time, and research site, for analysis.

2.5 Data Analysis Strategies

Quantitative data are much easier to analyze as they can be compared quickly using statistical data analysis software (Joyner et al., 2013). Quantitative researchers collect and analyze numerical data and this analysis begins at the conclusion of the data collection (Gay, Mills, & Airasian, 2009). For this research, the TQCs (teachers' qualification, teachers' certification, teachers' experience, professional development, and academic coaching), and the ordinal grades students received were assigned numerical codes, before uploading into SPSS Version 22.0 for analysis. Assumptions for Spearman's Rho correlation and Chi-Square analysis were run prior to the tests being conducted.

2.5.1 SPSS Version 22.0

This statistical software was used to compute descriptive statistics, Spearman's Rho correlation, and Chi-Square test of independence. The Bonferroni post hoc option was also used since three levels of independent variables were involved. This option adjusted 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 new associated probability value which was then compared with the adjusted

Bonferroni alpha level. This adjustment determined the exact position where the significance lay.

2.6 Validation Concerns

The reliability indices and validation procedures of this CXC, CSEC Mathematics examination were formally requested from CXC headquarters in Barbados on February 28, 2017, but this request was denied by the examination council, on March 02, 2017 on the grounds that such information is not divulged to the general public. Another formal request was made on October 17, 2017; at the time of writing, no response was received. However, other validity and reliability measures of this examination were extracted from the current CXC, CSEC Mathematics syllabus (2010-2016) and the 2016 annual technical report.

2.6.1 External Validity

The validity evidence for the 2016 CSEC Mathematics examination was obtained from the Mathematics syllabus (2010-2016) and the CXC annual technical report. These two documents were primarily used to discuss the content-related evidence of validity.

2.6.2 Content-Related Evidence of Validity

Gay, Mills and Airasian (2009) advanced that content-related evidence of validity requires both item validity and sampling validity. Item validity focuses on whether the test items are appropriate to the measurement of the intended content area while sampling validity is concerned with how well the test samples the total content area on the curriculum. Using the content knowledge received from two graduate programmes of study, coupled with the Mathematics teaching experience at Grade 12, the researcher compared the Mathematics syllabus (2010-2016) and the 2016 CSEC Mathematics examination Paper 02 for item validity. The topics, test items, and the marks allocation for Paper 02 were examined for sampling validity. Paper 01, of the CSEC Mathematics examinations, is never released to the general public. Hence, the content of Paper 02 adequately represented the CSEC Mathematics syllabus (2010-2016).

2.6.3 Generalizability

Merriam (2009) postulates that, to generalize within quantitative research, means to generalize to different situations through a priori condition such as equivalency between sample and population. Gay, Mills, and Airasian (2009) said that quantitative researchers do not generally gather information from the entire population, but if the sample selected adequately represents the population, the findings can be generalized to the target population. Therefore, for this research, the findings derived from the sample can be generalized to the CSEC Grade 12 Mathematics students from across the Caribbean region.

2.7 Ethical and Legal Issues

The ethical and legal issues are hallmarks of any research venture. It is critical that each participant be aware of what will transpire and not be caught by surprise (Seidman, 2013). Each gatekeeper and participant, involved in this research, were given adequate notice, engaged in ongoing discussions, and asked questions for clarification. Each participant was informed continually of the high level of confidentiality and ethical and legal issues that will be upheld in this research. They were reminded that their participation was entirely voluntary which suggested that they could withdraw from the research process at any time without prior notice or fear of being victimized. No information pertaining to providing an explanation, directly or indirectly, to the hypotheses was collected prior to the application to and the granting of permission by Northern Caribbean University (NCU) Institutional Review Board (IRB). Access and hierarchy, informed consent, and pseudonyms and anonymity were all part of this discussion regarding the ethical and legal issues within this research.

2.7.1 Access to Research Sites

The following steps were followed to gain access to the schools/research sites:

1. Preliminary contact was made with the CEO (ag) within the Ministry of Education and Culture, through writing, of my willingness to conduct research within the public secondary schools. Similarly, the school board within the private school was also contacted for the same reason.
2. Formal engagement was made with the CEO (ag) and the school board chairperson seeking permission to conduct my research at their respective schools. The researcher personally delivered a thank you letter addressed to the CEO (ag) and to the secretary of the private school board.
3. Meetings, with each school principal, were held and the permission letter received from the Ministry of Education and Culture was presented. This meeting was primarily to sensitize the principals about the research and to seek further permission to involve their Mathematics teachers of Grade 12. A letter requesting permission to use the private school was personally delivered to its principal.
4. Meetings, with the Mathematics Head of Department (HOD) and each Mathematics teacher of Grade 12, were held on the 10th and 15th February 2017. At these meetings, a commitment to participate in the study was requested, and an information sheet was prepared, collected, and securely kept under lock and key.
5. Permission was requested by the researcher and subsequently granted by CXC to scan the 2016 CSEC Mathematics examination Paper 02 to this document.

2.7.2 Informed Consent

The signing of informed consent forms is the first step in minimizing the risk participants' face (Seidman, 2013). The researcher will continue to keep these signed informed consent forms of the teachers in a secured location for at least five years before they are destroyed (Berg, 2009) by shredding. These are the steps that were followed that ensured the informed consent forms were completed:

1. Have an initial meeting with the potential teachers as participants.
2. Verbal consent was received from the potential participants to be part of the research process.
3. The researcher typed, printed, and personally delivered a copy of an invitation letter to each potential participant who agreed to be part of the research process.
4. The potential participants acknowledged the receipt of the letter of invitation.
5. The researcher issued each teacher as a participant with an informed consent form.

6. The signing of the informed consent form further indicated their commitment and willingness to participate in this research.

2.7.3 Pseudonym and Anonymity

Participants, as well as their schools/research sites, were assigned pseudonyms for the sole purpose of withholding their identity from the general public. The researcher ensured the following steps were taken as suggested by Seidman (2013) in order to protect the participants' identity:

1. The researcher made direct contact with each teacher as participant.
2. The teachers' demographic information was stored in a secure environment.
3. The researcher did not discuss the identity of the participants or the research sites.
4. Only the researcher had access to the pseudonyms used for each teacher and research site.

3. Results

There were two central quantitative research questions, with a total of eight related hypotheses. The test statistics incorporated were: (a) Spearman's rho correlation and (b) Chi-square. These two non-parametric tests were the most appropriate for this research since the students' grades, from the 2016 CSEC Mathematics examination, are ordinal (Gay et al., 2009). The demographic information of the eight teachers was categorical. The categorical data of the teachers' demographics and how each TQC was numerically coded are presented in table 3 below.

Table 3. Teachers' Demographic Information and Numerical Codes

Teacher Characteristics	Total Teachers	Numerical codes
College Major		
In-Field	5	1
Out-of-Field	3	2
Professional Certification		
Traditional Training	2	1
Alternative Training	3	2
Untrained	3	3
Mathematics Teaching Experience (Years)		
1-3	2	1
7-9	4	2
10+	2	3
Professional Development (Hours)		
25 or Less	3	1
26-50	3	2
51 or More	2	3

Academic Coaching (Hours)		
21-60	4	1
61-100	3	2
101 or More	1	3

Note. There are eight teachers and five TQCs. Each teacher identified their category on the demographic questionnaire that was provided. No teacher indicated that their experience was in the category 4-6 years.

3.1 Assumption for Spearman's Rho Correlation

According to Bastick and Matalon (2007), the Spearman's rho must be used when at least one of the variables is ordinal. Gay, Mill and Airasian (2009) said that both variables could also be ranked. For this research, the 2016 CSEC Mathematics grades students received are ordinal, hence, meeting this assumption. In addition, a monotonic relationship existed; when one variable increases the other increases or when one variable decreases the other decreases. The scatter plot derived showed a linear relationship between TQCs and students' ordinal grades. This interpretation must be made with extreme caution since the sample size is relatively small (N=113).

3.2 Assumptions for Chi-Square

Each TQC was treated as independent variables while the ordinal grades students received at the 2016 CSEC Mathematics sitting represented the dependent variable. The assumption of a non-normal distribution was met, even though it appears to be slightly normal. The histogram and the distribution curve in Figure 1 below, substantiate this claim.

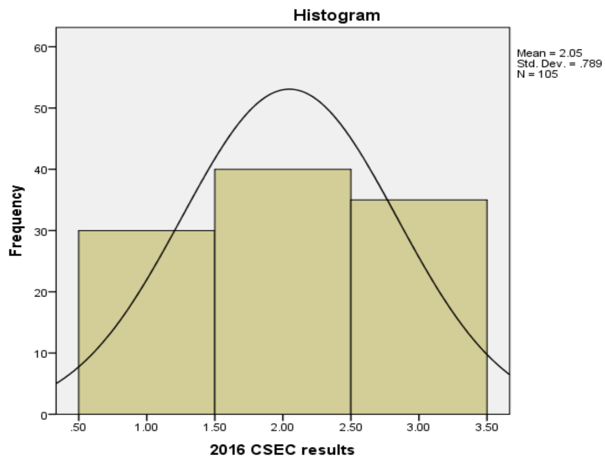

Figure 1. Distribution Curve Violates Normality

The second assumption for chi-square test: the expected frequencies for any expected cell must not fall below five counts, was also met. Each cell in the output table had an expected count of at least 7.43. Having met these assumptions, the Chi-Square non-parametric test was conducted to test the association between the TQCs and the ordinal grades students received at the 2016 CSEC Mathematics examination.

3.3 Research Questions and Hypotheses

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

The Alternative Hypothesis (H_a) is: There is a statistically significant relationship between teacher qualification characteristics (teachers' qualification, teachers' certification, teachers' experience, professional development, academic coaching) and students' mathematical achievement grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination.

The Null Hypothesis (H_0) is: There is no statistically significant relationship between teacher qualification characteristics (teachers' qualification, teachers' certification, teachers' 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 4 below presents the Spearman's rho correlation between CSEC Mathematics performance and TQCs.

Table 4. Spearman's Rho Correlation between 2016 CSEC Mathematics Results and Teachers' Qualification Characteristics, in the BVI

	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. N = 105, * Correlation is significant at the .001 level, ** Correlation is significant at the .05 level

3.3.1 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?

The output, in Table 4 above, reveals that there is a statistically significant positive relationship between teachers' qualification and students' ordinal grades with [r=.416; p=.000 < α=.001]. Hence, students with teachers who had Mathematics in-field majors had a corresponding increase in performance and this suggests that these students tend to receive the higher grades. Similarly, students who were taught by teachers with an out-of-field majors, tended to receive lower grades. The results further showed that the null hypothesis: There is no 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 (H_0), was rejected at .001 alpha level.

3.3.2 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?

The output revealed that there is a statistically significant positive relationship between teacher professional certification and students' ordinal grades with [$r=.235$; $p=.016 < \alpha=.05$]. Hence, students who were taught by teachers with a traditional certification are likely to receive higher grades. Similarly, students who were taught by untrained teachers are likely to receive lower grades. The results further showed that the null hypothesis: There is no 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 (H_0), was rejected at 5% alpha level.

3.3.3 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?

The output revealed that there is a statistically significant positive relationship between teachers' Mathematics teaching experience and students' ordinal grades with [$r=.20$; $p=.041 < \alpha=.05$]. Hence, students who were taught by teachers with 1-3 years of Mathematics teaching experience received higher grades than students who were taught by teachers with more years of teaching experience. The results further state that the null hypothesis: There is no 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 (H_0), was rejected at 5% alpha level.

3.3.4 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?

The output revealed that there is no statistically significant relationship between hours spent during teacher professional development and students' ordinal grades with [$r=.116$; $p=.237 > \alpha=.05$]. This suggests that the null hypothesis: There is no 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 (H_0), was retained at 5% alpha level. Hence, no further analysis and interpretation was made.

3.3.5 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?

The output revealed that there is no statistically significant relationship between hours spent engaged in academic coaching and students' ordinal grades with [r=-.52; p=.599 > α=.05]. This suggests that the null hypothesis: There is no statistically significant relationship between academic coaching of students by their Mathematics teachers (at most 60 hours, 61-100 hours, 101-140 hours) and the final grades (Grades *I, II, & III*) students received, as measured by the 2016 CSEC Mathematics May/June examination, was retained at 5% alpha level. Hence, no further analysis and interpretation was made.

From the Spearman's rho correlation analysis obtained in Table 4 above, it was revealed that of the five TQCs that were established in this research, only three were statistically significant. The three TQCs that showed statistical significance are: teachers' qualification, teachers' professional certification, and teachers' Mathematics teaching experience. The two TQCs that did not show statistical significance are: professional development and academic coaching. Hence, professional development and academic coaching were not part of the chi-square analysis below.

The central quantitative research question #2: Is there a statistically significant association between teacher qualification characteristics and students' mathematical achievement grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination?

The Alternative Hypothesis (H_a) is: There is a statistically significant association between teacher qualification characteristics and students' mathematical achievement grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination.

The Null Hypothesis (H_0) is: There is no statistically significant association between teacher qualification characteristics and students' mathematical achievement grades (Grades *I, II, & III*), as measured by the 2016 CSEC Mathematics May/June examination.

3.3.6 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?

The null hypothesis: There is no 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, was rejected with [p=.000 < α =.001]. This suggests an overall statistically significant association between the teacher qualification (in-field and out-of-field) majors and students' achievement. Based on the number of students who received acceptable grades (N=105) it was likely that students who were taught by teachers with an in-field major were likely to perform better than students who were taught by teachers with an out-of-field major. This analysis might be due to the small sample size and the fact that there were five (63%) in-field teachers. Table 5 below reflects the output of this data.

Table 5. Chi-Square Output Table for Teachers' Qualification/College Major in the BVI

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

3.3.7 Research Question 2b

The second related research question: 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?

The null hypothesis: There is no 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, was rejected with [$p=.010< \alpha =.05$]. This suggests an overall statistically significant association between teachers' professional certification (traditional, alternative, or untrained) and students' achievement. Table 6 below shows the output table for teachers' certification.

Table 6. The Chi-Square Output Table for Teachers' 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

A Post Hoc Test with an adjusted Bonferroni alpha level was applied to determine where the statistically significant association lay within the Chi-Square. This is adequate because there were three levels within the independent variable in this research question. Table 7 below shows the summary of the corrected Bonferroni Post Hoc test. The statistical significance lies only between students who received Grade *III* passes and teachers who are untrained.

Table 7. Bonferroni Adjustment and Teachers' 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

3.3.8 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 null hypothesis: There is no 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, was rejected with [$p=.003< \alpha =.05$]. This suggests an overall statistically significant association between teachers' Mathematics teaching experience (1-3 years, 7-9 years, and 10+ years) and students' achievement. Table 8 below shows the output table for teachers' experience.

Table 8. The Chi-Square Output Table for Teachers' 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

A Post Hoc test was used to determine where the statistically significant association or associations lay. The post hoc test results revealed that with the Bonferroni adjustment for teachers' Mathematics teaching experience, that the significance lies between the observed and expected results of students receiving Grade I passes who had teachers with 1-3 years of experience. Also, significance lies between the observed and the expected performance of students receiving Grade *III* passes in Mathematics who had teachers with 7-9 years of experience. Table 9 below shows the summary of the corrected Bonferroni Post Hoc test.

Table 9. Bonferroni Adjustment and Mathematics Teachers' Experience Statistical Value

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

3.4 Post Hoc Test

The TQCs in this research were categorized. Teachers' qualification had two categories, while teachers' professional certification and teachers' Mathematics teaching experience had three categories each. Each of the null hypothesis showed an overall statistical significance. However, the post hoc test only applied to teachers' professional certification and teachers' Mathematics teaching experience, since they both had more than two independent categories. To conduct the post hoc test, the outcome in each cell was converted to an adjusted z-score and then to new associated probability values which were then compared with the adjusted Bonferroni alpha level. The post hoc test identified exactly where the significance among the variables lay using adjusted Bonferroni alpha levels. The adjusted alpha level was computed by dividing, α, by the number of independent observations or cells in chi-square (χ^2) analysis (Bastick & Matalon, 2007). There were nine (9) independent observations in this analysis and alpha level was .05. Therefore: α/9 = .05/9 = .00555. Hence, the new level of significance (alpha level) was adjusted to (α=.00555) for teachers' professional certification and teachers' experience.

4. Discussion

This research utilized the Spearman's rho correlation and Chi-square to explain the relationship and association between TQCs and students' 2016 CSEC Mathematics achievement at two secondary schools in the BVI. The sample size (105 students and 8 teachers) for this study was relatively small (N=113) and therefore readers should exercise extreme caution when interpreting the results.

4.1 Discussion of Findings for Teachers' Qualification

The findings revealed that students who have teachers with an in-field Mathematics major are likely to outperform students who have teachers without an in-field Mathematics major. This appears to be the reason more students, approximately twice as many, were taught by in-field Mathematics majors. The level of students' achievements was dependent on their teachers' major.

The findings of this current research are supported by Musau and Abere (2015). Their study employed ex-post-facto survey research design and the purpose was to determine the extent to which teacher qualification was related to students' academic performance in Mathematics, Biology, Chemistry, Physics, and Agriculture. Teacher qualification was sub-divided into four categories: Diploma certificate holders, trained graduate teachers, untrained graduate teachers, and post-graduate degree holders. These categories were compared with the students' average mean scores in the above mentioned subject areas for all the teachers who taught the candidates in the sampled schools. The specific research question that guided the study was: To what extent does teacher qualification influence students' academic performance in SMT subjects (Mathematics, Biology, Chemistry, Physics, and Agriculture) at form four level? Teachers who taught these subjects were trained in their specific content area.

The findings indicated that the mean score of students taught by Post- Graduates were much higher than that of students taught by Untrained Graduates. Students taught by Trained Graduates performed significantly better than those taught by Untrained Graduates. In addition, the findings revealed that Mathematics was taught by most SMT teachers as represented by 26.4%. The findings further indicated that most of the candidates scored low grades in SMT subjects while only a few scored quality grades.

4.2 Discussion of Findings for Teachers' Certification

There is an overall 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. The Bonferroni Post Hoc Test was run to determine where specifically, the significant difference or differences lie within the Chi-square analysis. The results revealed that for the Bonferroni adjustment for teacher certification route, the statistical significance lay only between students who received Grade I passes in CSEC Mathematics and teachers who are untrained.

It was surprising that statistical significance was found between students who received Grade 1 passes and untrained teachers. This can be directly due to other factors and not certification. Being uncertified does not suggest incompetence in the subject area being taught. However, teachers should be encouraged to receive professional training (traditionally or alternatively), since trained teachers can lay the foundation, at earlier grade levels, for students writing their examination at Grade 12.

The findings of this research are supported by Matagi-Tofiga (2011) who hypothesized that the outcome of his research revealed a significant relationship between teachers' certification and students' achievement in Mathematics. Blazer (2012) concluded in his research that alternatively certified teachers could produce students' achievement gains comparable to teachers who have been traditionally certified.

The purpose of Rieke's (2011) study was to determine if there was a statistically significant difference in students' growth in Mathematics learning between those students who were instructed by a secondary certification pathway teacher and those whose teacher took an elementary pathway to certification. This analysis found that students' achievement growth, in Mathematics, are statistically significantly greater for those students whose teacher gained certification through a secondary pathway instead of the elementary pathway. A total of 3991 students were involved in this study, covering 85 schools, in 55 school districts throughout the state of Indiana.

4.3 Teachers' Mathematics Teaching Experience

There is an overall 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 Bonferroni Post Hoc test was conducted to determine where the statistically significant association or associations lay within the Chi-square. The results revealed that there is statistical significance between students who received Grade *I* passes and teachers who have 1-3 years of Mathematics teaching experience. Also, there is statistical significance between students who received Grade *III* passes and teachers who have 7-9 years of Mathematics teaching experience.

The findings suggest that students who have teachers with 1- 3 years of teaching experience can out-perform students who are taught by teachers with 7-9 years of teaching experience. This explains why fewer teachers have 1-3 years and 10+ years of teaching experience than teachers with 7-9 years of teaching experience. It would appear that students who have teachers with the least number of years (1-3 years) could receive higher grades than students who have teachers with more years of teaching experience, but this interpretation should be done with extreme caution since the students who participated is relatively small (N=105).

This current research was supported by Sandoval-Hernandez, Jaschinski, Fraser and Ikoma (2015). The purpose of this study was to determine the relationship between teacher experience as measured by years of teaching and student achievement in fourth-grade Mathematics by using international comparative data. This was achieved by answering two research questions: Is teacher experience associated with student Mathematics achievement of fourth graders in the education systems analyzed? How does this association change when other teacher characteristics are taken into account?

The data collected and analyzed represented the average Mathematics achievement scores of students as broken down by teachers' reported years of teaching experience for the 55 education systems analyzed. The findings revealed that in 20 education systems, the students of teachers with 20 or more years' experience had the highest average achievement. Across all education systems, the students of teachers with less than five years of teaching experience achieved an average of 486 score points in Grade 4 Mathematics, while the students of teachers with 20 or more years of experience achieved an average of 498 score points. As can be observed, on average, there is a pattern suggesting that students taught by teachers with more teaching experience tend to have higher achievement scores. This pattern, however, was not evident in all education systems. Education systems with the highest average achievement correspond to students of teachers with 5 or less years of experience. On the other hand, Stanford (2014) said that students in classrooms with teachers with five or less years of teaching experience scored significantly lower than students who are taught by teachers with more than five years of teaching experience.

5. Conclusion

The level of pedagogy in a secondary school Mathematics classroom and teachers' qualification characteristics are key to students' academic achievement. Mathematics education and development are relevant and fundamental to the economic and scientific growth of the Caribbean region. The ever widening gap between the performances of CSEC Mathematics students, within the Caribbean region, has prompted this research. There were 105 students and eight teachers who participated in this research from two research sites, in the BVI. There were a total of eight research questions and their related hypotheses that tested for the relationship and association between variables. Spearman's rho correlation was used as the initial statistical measure to test for relationship between TQCs and students' Mathematics achievement as measured by the 2016 CSEC Mathematics examination. However, three TQCs (teachers' qualification, teachers' certification, teachers' experience) were found to be statistically significant; teachers' qualification at .1% and teachers' certification and teachers' experience at 5% level of significance. Only these three TQCs were further tested using chi-square. The Chi-Square statistical procedure was used to test for statistically significant association between the variables. The Bonferroni post hoc test was used to adjust alpha level of significance. More studies need to be done, but with larger sample sizes.

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