THE ADVANTAGE OF MALES WRITING THE CCSLC MATHEMATICS EXAMINATION PRIOR TO THE CSEC MATHEMATICS EXAMINATION: A STATISTICAL JUSTIFICATION FOR MANDATORY IMPLEMENTATION

by

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A Dissertation
Submitted in Partial Fulfillment
of the Requirements for the
Doctor of Education (Ed.D)

School of Business and Education
Gwynedd Mercy University
Gwynedd Valley, Pennsylvania
December 2022

The Advantage of Males Writing the CCSLC Mathematics Examination Prior to the CSEC Mathematics Examination: A Statistical Justification for Mandatory Implementation

We, the Dissertation Committee, certify that we have read this dissertation and that, in our judgment, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Education.

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Abstract

The purpose of this quantitative study was to provide statistical evidence to support that if males take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination, they will have a statistically significantly higher average score than those who only take the CSEC mathematics examination. In addition, the study also proposed statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant difference between the average female and average male scores on the CSEC mathematics examination for those between 14 and 19 years old. With respect to research question one, the results indicated that male students who wrote the CCSLC mathematics examination before the CSEC mathematics examination received a statistically significantly higher mean score than their male counterparts who only took the CSEC mathematics examination. With respect to research question two, when compared to female students who wrote the CCSLC mathematics examination before taking the CSEC mathematics examination, the results indicated that the male students who wrote the CCSLC mathematics examination before the CSEC mathematics examination mean score was marginally higher than the female student. Although the male students' score was marginally higher than the female student, based on the two-sampled independent t-test, there was no statistically significant difference in mean scores.

Keywords: Mathematics Education, Educational Statistics, Critical Race Theory (CRT), Male Success, Gender in Mathematics, Educational Policy, Social Learning Theory, Humanism Learning Theory, System Hybridism Learning Theory (SHLT)

Dedication

This research is dedicated to my daughter, Celina, and son, Aidan. I also dedicate this research to my parents, partner, brother, sister, extended family, Masonic brothers, professors, friends, colleagues, and employer for supporting and being patient with me during this period of additional intense doctoral study.

My partner deserves a special dedication for being at my side for the past twenty years and being there for our two children while I completed my research. She was able to manage my five-year-old daughter and three-year-old son while I concentrated on my studies.

I want to thank my father and mother, who laid the primary foundation of excellence and discipline. My parents inspired me to pursue excellence in everything that I do.

An honorable dedication to my late grandfather, ‘Daddy Browne,’ and grandmother, ‘Doie,’ who passed before I started this doctoral degree. I am sure they would have been as supportive as they always were regarding my educational pursuits.

In the words of Scottish Anglican
Henry Francis Lyte

“…What but Thy grace can foil the tempter's power?
Who, like Thyself, my guide and stay can be?
Through cloud and sunshine, Lord, abide with me.
I fear no foe, with Thee at hand to bless;
Ills have no weight, and tears no bitterness….”

Acknowledgments

I wish to acknowledge my family, brothers, and friends for making this journey a reality. I would also like to thank my advisors, Dr. Atasha Quarles, Dr. Tamarah Smith, and Dr. Catherine Perkins, for their constructive feedback that assisted in completing the dissertation and making the experience a rigorous next enjoyable one. Finally, the Federal Government of the United States of America deserves special acknowledgment for providing the funding that assisted significantly in completing this degree.

All glory to the Most High!

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Chapter 1—Introduction

1.1 Background

In 2007, the Caribbean Examinations Council (CXC) introduced the Caribbean Certificate of Secondary Level Competence (CCSLC) examination to "…certify the knowledge, generic competencies, and attitudes and values that all secondary school leavers should have attained" (Caribbean Examinations Council, 2021). Further to the implementation across the Caribbean region, initial candidate registration across all subjects offered at the CCSLC level was 6,797 in 2007, as seen in the Caribbean Examinations Council (2007). One thousand, nine hundred and fifteen (1,915) of those registrations were for mathematics, and 866 registrants were male. By 2018, the number of candidates registered for CCSLC mathematics was 3,964, of which 1,960 were male (Caribbean Examinations Council, 2018).

The problem of below-average performance on the Caribbean Secondary Education Certificate (CSEC) mathematics examination has been an issue for more than five years. More directly, male performance on the examination is statistically significantly lower when compared to female performance, as evident in the Caribbean Examinations Council (2022). The average normalized score (**/100) for all males in the representative sample between the age of 14 and 19 across all territories registered for the examination in the Caribbean between 2018 and 2020 that wrote the CSEC mathematics examination without writing the CCSLC mathematics examination was 34.54. The normalized average score for females who wrote the CCSLC mathematics examination before the CSEC mathematics examination was 35.78. To conduct further statistical analysis, 4,667 candidates from the total population allowed for an acceptable sample. The comparison between the means allowed us to validate the distributions using the selected sample from the total population. Although the scores may appear to be a marginal

difference, the problem still exists that the average male performance is below the average score in CSEC mathematics across the population. The importance of comparing male and female performance on the CSEC mathematics examination has been a topic of discussion; however, the larger context of the overall performance of students on the CSEC mathematics examination has also presented its challenges concerning total population performance. Without a doubt, a more generalized approach to the implementation of support programs across the Caribbean region is necessary to address the overall performance of the total population. As a matter of evidence-based decision-making, the study addresses this problem with particular focus on the male population to present a case to support the mandatory implementation of students taking the CCSLC mathematics examination before the CSEC mathematics examination. The motivation behind such a change is the fact that the design of the CCSLC mathematics examination assesses mathematics literacy that prepares students for more advanced mathematics studies. Making this examination mandatory will prepare students for the more advanced CSEC mathematics examination. The description of the CCSLC mathematics examinations clearly outlines these benefits, as seen in the Caribbean Examinations Council (2015).

As the world moves more towards technologically driven processes, skills in the sciences and mathematics will become mandatory. Hence, students must prepare to continue their learning and certification at the tertiary and professional levels. According to Marrett and Gates (1983) and Williams et al. (2019), a more holistic approach to improving the performance in mathematics of Black males was still a topic for discussion concerning developing methodologies and policies that will yield positive results. Research to date has also been minimal, focusing on the Caribbean region. This research seeks to present statistical evidence that would infer that a positive step in a more holistic approach to addressing the

underperformance of males in mathematics requires a policy decision by participating governments to make the CCSLC mathematics examination mandatory before taking the CSEC examination.

1.2 Statement of the Problem

Males in the Caribbean underperform on the Caribbean Secondary Education Certificate (CSEC) mathematics examination, resulting in the lack of matriculation to post-secondary programs requiring CSEC mathematics. The paucity of enrollment in post-secondary programs, mainly colleges and universities, affects the human development capital throughout the Caribbean region, which results in a less competitive global male citizen. Knowing this, the ability to significantly increase the average score on the CSEC mathematics examination will improve international competitiveness and the ability for matriculation requirements to be met.

Recent studies by Davis et al. (2019), Davis (2018), Harris (2018), Hunter and Stinson (2019), Jones (1987), Marrett and Gates (1983), Williams et al. (2019), and Williams (2017) focused on the importance of developing policies and methodologies that are holistic. Providing Black males with the tools and support necessary to succeed in mathematics at the pre-tertiary and tertiary levels were highlighted in the literature. Davis et al. (2019) and Williams et al. (2019) studied these issues within the context of the North American perceptive. Studies addressing the problem with a particular focus on the Caribbean region are exiguous.

This research addresses the gap in the literature by presenting a case based on statistical evidence that supports the mandatory implementation of the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before writing the CSEC mathematics examination, especially for male candidates between 14-19 years old. Although this requires

changes to school policies across the Caribbean, the evidence for such a change is necessary given the technological drive as a significant policy position across the Caribbean region (Caricom, 2014). Furthermore, this policy posits to be beneficial to the human development capital of the Caribbean, which may eventually realize benefits to economic growth and sustainability.

1.3 Purpose and Significance of the Study

The study aims to provide statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination have a statistically significantly higher average score than those who only take the CSEC mathematics examination. In addition, the study provides statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant difference between female and male average scores on the CSEC mathematics examination.

Based on the policy direction in the Caribbean Region concerning developmental and educational policy decisions to advance the science, technology, engineering, and mathematics subjects in the context of future casting for social and economic development, this study will provide evidence to support the mandatory implementation of the CCSLC mathematics examination for male students (Caricom, 2014). The results from this study will also significantly contribute to the body of knowledge in the Caribbean context of mathematics education and student performance for those between 14 and 19 years old. Another benefit of this study is that it will provide statistical evidence to allow teachers, administrators, and policymakers to make evidence-based decisions regarding implementing educational programs.

1.4 Research Objectives

This research aims to achieve the following research objectives:

1. To provide statistical evidence that males who take the CCSLC mathematics examination before the CSEC mathematics examination have a statistically significant higher average score than those who only take the CSEC mathematics examination.
2. To provide the statistical evidence to show that if males take the CCSLC before the CSEC mathematics examination, there is a statistically insignificant difference between female and male average scores on the CSEC mathematics examination.

1.5 Research Questions and Hypotheses

The following research questions (RQ) and hypotheses (H) guided the dissertation and met the objectives of the research:

RQ_1: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?

RQ_2: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) examination result in a statistically insignificant difference between the average female and average male scores on the CSEC mathematics examination?

$H_{1\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will not be a statistically significant increase in the average score.

$H_{1\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will be a statistically significant increase in the average score

$H_{2\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically insignificant difference between the average female and male scores.

$H_{2\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically significant difference between the average female and male scores.

1.6 Limitations and Delimitations

This dissertation used a data sample of 4,667 candidates from an examination board in the Caribbean Region between 2018 and 2020 linked to the May/June examination session. The data was limited to Caribbean region territories that wrote the CSEC and CCSLC examinations. The data-columnized matrix structure was examination session, territory, examination type, final score, normalized score, grade, and gender. In addition to the sample selected, this study focuses primarily on male performance with an outlook on how to increase their average score. Although this limitation exists concerning the focus of this group of candidates, there is still enough evidence based on the literature review to justify why the need for a policy change is necessary. To address this limitation, future studies should use a larger dataset with more observations to determine the impact of different policy combinations that may yield more significant increases in the average score of Black males writing the CSEC mathematics examination. It may also be necessary to address the problem in different age groups and not only limited to the sample of

14-19-year-olds. However, for this study, the sample selected has sufficient statistical power to generalize the findings given the context of the Caribbean region.

1.6 Researcher Assumptions

One assumption is that the format and structure of the CCSLC and CSEC examination will not change in the near future. Accordingly, the CCSLC mathematics examination and CSEC mathematics examination are assumed to be an acceptable benchmark to generalize the results to male students in the Caribbean studying mathematics.

This study assumes that the sample generated based on a weighted random sampling method captures a diverse enough population to generalize the results to similar groups. The assumption is that combining humanism learning theory and social learning theory as a basis for proposing the development and use of the system hybridism learning theory in this study can inform educational policy.

1.7 Definition of Key Terms

Caribbean Region. For this dissertation, the Caribbean Region is the territory that wrote the CCSLC and CSEC. The Region is Anguilla, Antigua and Barbuda, Barbados, Belize, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad, and Tobago, and the Turks and Caicos Islands (Caribbean Examinations Council, 2019).

CCSLC. The first offering of the Caribbean Certificate of Secondary Level Competence (CCSLC) was in June 2007. The design of the CCSLC responds to the changing demands of

education to certify the knowledge, generic competencies, attitudes, and values that all secondary school leavers should have attained (Caribbean Examinations Council, 2021).

CSEC. The Caribbean Secondary Education Certificate (CSEC) examinations assess and certify a student's academic achievement after five years of secondary school. In addition, there are two Proficiency Schemes for the CSEC: General and Technical (Caribbean Examinations Council, 2021).

CXC. The Caribbean Examinations Council (CXC) was established in 1972 under an Agreement by the Participating Governments in the Caribbean Community (CARICOM). CXC assures the global human resource competitiveness of the Caribbean through the provision of syllabuses of the highest quality; valid and reliable examinations and certificates of international repute for students of all ages, abilities, and interests; services to educational institutions in the development of syllabuses, assessments and examinations' administration, in the most cost-effective way, (Caribbean Examinations Council, 2019).

SHLT. System Hybridism Learning Theory (SHLT) is a conceptual framework that integrates student experience, humanism learning theory, and social learning theory into a continuous process. The SHLT uses a continuous semi-sequential probabilistic network system configuration. The framework has four main elements: input, process, output, and feedback. The input element consists of the student/candidate, educational policies, support programs, student experience, and the two working theories. The processing element is the section that formulates and integrates all the inputs, eventually leading to the output of examination scores. Finally, the linkage of the examination scores and candidate is in the feedback element.

1.8 Summary

This chapter outlines the background, justification, and rationale to address the problem of males in the Caribbean underperforming on the Caribbean Secondary Education Certificate (CSEC) mathematics examination. In the larger context of the Caribbean region regarding the total population performance on CSEC mathematics, the sample selected had enough statistical power to justify the findings to address the underperformance problem with a particular focus on the male population. The dissertation outline is as follows; Chapter 1 includes the background of the problem, the problem statement, the purpose statement, research objectives, research questions, hypotheses, and the research limitations and organization. Chapter 2 presents the literature review. Chapter 3 explains the methodology and techniques for generating the results. Also, it explains the statistical procedures for determining evidence-based policy decision-making. Chapter 4 provides the results from statistical analysis based on the hypotheses. Finally, chapter 5 summarizes the research, conclusions, and future recommendations for researchers to build on this research.

Chapter 2—Literature Review

2.1 Introduction

The purpose of this quantitative study was to provide statistical evidence to support that males who take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination have a statistically significantly higher average score than those who only take the CSEC mathematics examination. In addition, the study also proposed statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant difference between female and male average scores on the CSEC mathematics examination for those between 14 – 19 years old. Previous studies identified the need for male students to be exposed to better support systems in the study of mathematics to perform optimally on high stake examinations.

The strategy used to review the literature was a deep dive approach. The deep dive approach consisted of five (5) main steps:

1. Recognize the problem as part of a bigger problem but focus on the literature that attempts to fill the gap or offer a solution.
2. Collect all information, including scholarly journal articles, previous dissertations, and other documents that assist in better understanding approaches to solving the problem.
3. Compile the information into a logical flow of theories, facts, and data.
4. Evaluate the relevance and importance of the literature.
5. Integrate the literature analysis into the proposed problem solution by showing how this approach narrows the gap in the literature and adds value.

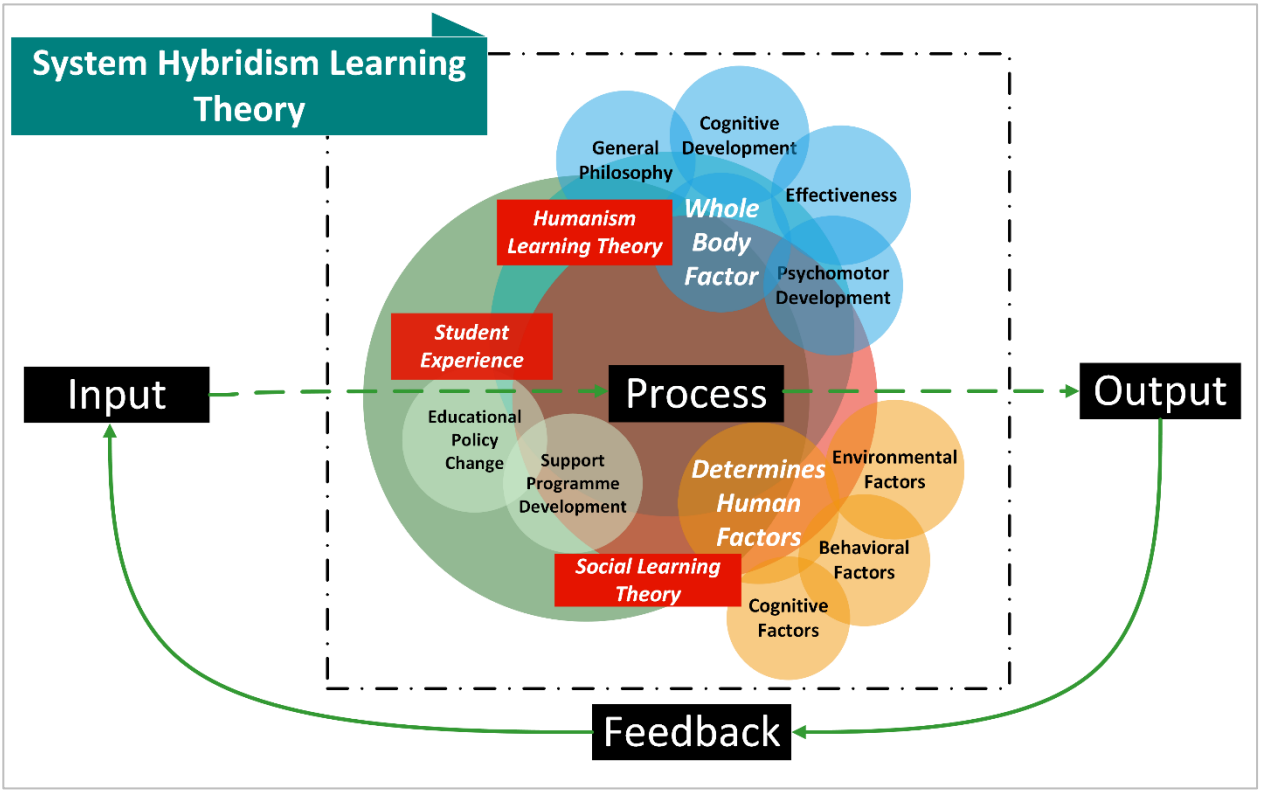
Critical theoretical concepts such as the application of humanism learning theory and social learning theory are central to the improvement and sustainability of student learning and development. For example, Cunningham and Gomez (2021) noted that many Black students experience informal learning outside the classroom, which influences their ability to understand and conceptualize mathematical concepts. Furthermore, it introduces the social learning theory coined by Bandura (1977), which recognizes the mediating process between stimuli and responses as a basis of learning from the environment through observation. More directly, Gonzalez et al. (2020) further explain that identifying the group of learners as marginalized due to race and community affiliation is essential in learning mathematics. Furthermore, it should inform the approach to learning concerning support materials and systems.

Apart from social learning theory as a primary foundation for learning, Qadry et al. (2021) explored humanism learning theory as another foundation since the best learning occurs when the whole person is inclusive of the cognitive, affective, and psychomotor is involved. Humanism learning theory, built on the general philosophy that the context of values, religion, culture, and ideology informs the learning process, can be linked to mathematics education. It would logically follow that this theory can inform the level of differentiation of mathematics learning based on the students' needs. Therefore, if applied directly to Black males, it is possible to develop policies and programs that treat the immediate needs of different learning groups. To make the linkages between other learning theories and, more directly, social learning theory and humanism learning theory, I introduced the proposed concept of a system hybridism learning theory (SHLT) as a working theory that can combine social learning theory and humanism learning theory into a conceptual framework.

2.2 Theoretical and Conceptual Framework

Figure 2-1.

System Hybridism Learning Theory (Griffith, 2022a)



This study aimed to justify the need to make taking the CCSLC mathematics examination before the CSEC mathematics examination mandatory for students and, more directly, male students. The guiding conceptual, theoretical framework, as seen in Figure 2-1, is used to draw relationships among the common themes of the literature to explain the concepts featured in the dissertation. The current literature examined seeks to lay a foundation for establishing a basis for implementing a policy change that requires writing the CCSLC mathematics examination before the CSEC mathematics examination.

Further to this, the identification of the primary input variable, the student, is of greatest importance in explaining the process of the system hybridism learning theory. The process section of the theory is where most of the explanations of the interactions among the student process factors exist. Further discussion allows for the identification of the gap in the literature. Assuming that all parts (set and subsets) in the process section of the theory are interdependent, mutually inclusive, and share continuous semi-sequential probabilistic factors, it produces an output (examination results) which is then attached to a feedback loop that influences the primary input variable, the student. The subsections allow for further discussion.

2.3 Learning Theories and Males in Mathematics

The use and implication of various learning theories in the teaching and learning of mathematics are fundamental to students' success. In this study, there is a particular focus on the use of social and humanism learning theories. It is of particular interest as it forms the foundation for the birth of the system hybridism learning theory, a framework that integrates both social and humanism learning theories. For example, the results of a study by Maple and Stage (1991) suggest that across groups inclusive of the Black male, Black female, and White male subgroups compared to White female subgroups, the Black groups displayed twice as much variance when it came to the study of mathematics. The implication for such results suggests significant variability in mathematics learning for Black students compared to White students. After that research by just a decade, a study by Baranchik and Cherkas (2002) highlighted that out of a sampled group of 2,000 students inclusive of Asian, Black, Hispanic, and White students, Black students, especially Black males, learned disproportionately fewer mathematics skills using precalculus as a benchmark.

Fifteen years after Baranchik and Cherkas (2002) study, Wilson-Akubude (2017) used a phenomenological approach to question Black males' performance in rigorous mathematics courses to identify those variables contributing to their overall performance in the subject. Wilson-Akubude (2017) recognized that the underachievement rate between Black male students and their White counterparts was conclusive that their general performance was below average in comparison. During the interview process, two (2) main variables contributed to the performance of Black male students in mathematics: (1) the support from the institution and (2) support from their family and community members. In social learning theory, these are considered environmental factors that contribute to determining the human factors. In humanism learning theory, these variables are considered part of the effectiveness factor contributing to the whole-body factor. The integration of these two theories forms an integral part of the student's experience, as seen in Figure 2-1.

In a somewhat inverted study that tried to determine the lack of motivation in female and African American students in mathematics at the middle school level, Dombrowski (2015) showed that teacher support was more strongly associated with motivating male students than female students. The variables investigated were mathematics motivation, teacher support, and student characteristics inclusive of race and gender. The results of the multiple regression analysis indicated that males close to the end of the middle school became more motivated while females approaching the end of middle school were less motivated, creating a gender motivation gap. When comparing this study to that of Ennis (2011), Walters Jr. (2016), and Henry-Burrell (2020), whose studies were on average four and a half years apart, a common theme emanated: 1) the need for male students to feel a high level of mathematics self-efficacy and 2) the need to have peers, teachers, and family support.

2.3.1 Gender Similarities and Differences in Mathematical Development

Gender similarities and differences in mathematical development for many years formed much discussion. More directly, scientists, educators, and policymakers have debated the issue of equality and fairness as it relates to teaching and learning needs. Therefore, this study recognizes this area as a need for review as it has implications for education policy development and practice related to mathematics education.

Rončević Zubković et al. (2021) explored age and gender, motivation, and emotional and cognitive factors in mathematics. The results suggested that as students aged, they became less motivated, especially during a period of school transition. For older students, the concept of mathematical value and mathematics self-concept are minor. Emotional factors such as anxiety were more prevalent in female students, while male students were less anxious about mathematics performance. The student's age did not affect anxiety as this emotion was consistently less dominant in males than females. Cárcamo et al. (2020) noted that the main focus is the evaluation of the differences in self-concept, subjective value, expectations, and academic performance related to mathematics and language. They were 406 participants from the 4^{th} and 5^{th} grades. Although the study was not focused on Black males, the aim was to establish if the differences among variables were statistically significantly different concerning gender. The results indicated that females showed higher performance expectations in mathematics and language. There were no gender differences concerning self-concept and subjective value. In addition, the variables self-concept, personal value, expectations, and academic performance investigated are subsets of the general philosophy, cognitive development, and psychomotor development in humanism learning theory and the behavioural and cognitive factors in social learning theory.

Pina et al. (2021) quantitative study focused on gender differences by examining the basic calculation skills needed for more complex problems. Although the scientific literature on gender differences in mathematical performance is inconclusive, evidence still indicates that Trends in International Mathematics and Science Study (TIMSS) show statistically significant performance differences between males and females. Therefore, the administration of a basic mathematical test that included symbolic and non-symbolic magnitude comparisons, fluency, and calculation in mathematics further investigates the hypothesis that there is no significant difference in performance between males and females. The results indicated no statistically significant difference between genders in the mean performance, variance, or percentiles. In addition to actual mathematics performance and the inconclusiveness of facts to suggest that there is a statistically significant gender difference in mathematics performance, limited evidence for intrinsic biological gender differences in mathematics ability has fueled debate about the underrepresentation of girls and women in science, technology, engineering, and mathematics (STEM), (Pina et al., 2021).

Kersey et al. (2019) examined the origins of mathematics ability and whether there are any gender differences. The main research question was whether males and females begin development with biological differences in mathematical processing. Other research questions were: Can the neural processes underlying mathematics development in females and males between the ages of 3 and 10 years affect their performance on mathematics assessments? Intrinsic biological and socio-cultural factors were used as a comparative framework to conclude mathematics ability in females and males.

In addition, Kersey et al. (2019) further investigate the differences among the functional magnetic resonance imaging (fRMI) results concerning the overlap of neural similarities in

females and males related to mathematics development. The results indicated that females and males showed significant gender similarities in neural functioning. Furthermore, they both engaged the same neural system during mathematics development, concluding that there were no biological advantages between genders.

Similar to the study of Kersey et al. (2019), Harris et al. (2021) focused on biological constructs that investigated the role of spatial orientation and gender in the relationship between spatial reasoning and mathematics. The purpose of the study was to examine three spatial reasoning constructs (mental rotation (MR), spatial visualization (SV), and spatial orientation (SO) to identify their contributions to mathematics performance in two samples (Study 1: grade 5; Study 2: grade 8). The research questions were, what are the unique contributions of different spatial constructs, namely MR, SV, and SO, to mathematics performance for students in 5^{th} and 8^{th}-grade cohorts? Does gender influence the relationship between spatial reasoning and mathematics at two middle-school time points? This study used a spatial reasoning construct to identify contributions to mathematics performance between male and female students. The results from Harris et al. (2021) indicated that spatial factors accounted for 51% of the variance in mathematics scores in Study 1 (grade 5) and 32% of the variance in math scores in Study 2 (grade 8). In both studies, spatial factors predicted a more significant proportion of geometry–measurement variance than number sense. The results indicated that spatial orientation was a unique contributor in all mathematics models; object-based spatial skills varied in their contribution to mathematics performance depending on mathematics content and gender. Therefore, it can be concluded that there are some differences between males and females as it relates to spatial orientation in the spatial-mathematics relationship but does not translate to other forms of the mathematics content. Coincidentally, the variables investigated in Kersey et al.

(2019) and Harris et al. (2021) are elements of cognitive development and psychomotor development in the humanism learning theory and the cognitive factors in the social learning theory.

While shifting from mostly intrinsic biological gender differences to psychological and socioeconomic differences across gender, Chiu (2021) investigated the gender differences related to effective parenting strategies for adolescent mathematics achievement. A bio-ecological model formed the basis of research. Chiu (2021) used a latent growth curve model to fit a Taiwan Education Panel Survey data. The analysis revealed that female performance was fitted to a quadratic development model, while male performance was a more linear fit. The results indicated that the mothers' monitoring and support model was the only effective parenting strategy for both genders in early adolescence. However, in later adolescence, fathers' monitoring was more effective on males, while the female response to this monitoring was more of a peripheral role. Mothers played a more direct role in listening and persuasion for males, while females had a rational role. Chiu (2021) noted that the findings support the bioecological model of differential model fit and effective parenting strategies between genders. Similar to the previous study, the investigated variables can be linked directly to cognitive development, effectiveness, and psychomotor development in the humanism learning theory and the social learning theory's cognitive, environmental, and behavioural factors.

Besides biological and general cognitive factors, Rahe and Quaiser-Pohl (2021) examined the emotional factors manifested through anxiety. There was a further investigation into mathematics anxiety between genders with a population of 97 children (54 females, 45 males) between 11 and 15 years. In addition, a second group comprised 84 undergraduate students (59 females, 25 males). The participants received a mental-rotation test where their

performance was rated. On completing the test, they received a questionnaire about mathematics anxiety. Rahe and Quaiser-Pohl (2021) findings indicated that gender differences increased with age and mental-rotation performance, and perceived mental-rotation performance were significant variables in gender difference in mathematics.

A similar study by Kyaruzi (2021) focused on the impact of gender on the sources of students' self-efficacy in mathematics in Tanzanian secondary schools. The sample comprised 267 (grade 11) from three (3) public schools. The students received a validation questionnaire to capture student responses to mastery experience, vicarious experience, physiological state (anxiety), and social persuasions. The results indicated that the four variables identified best described the sources of students' self-efficacy in mathematics. The latent mean analysis also revealed statistically significant gender differences in the students' perception of mastery. The factors such as mastery experience, vicarious experience, and physiological state (anxiety) are elements linked to the humanism learning theory's effectiveness and cognitive development factors. In contrast, the physiological state (anxiety) is an element in social learning theory's cognitive and behavioural factors. Social persuasions are elements shared between the general philosophy in humanism learning theory and the environmental factors in social learning theory.

Espinoza and Taut (2020) examined psychological variables such as perception of teachers' support and expectation, self-reported attitudes, and achievement. The study consisted of 1,380 Chilean students sampled from 41 schools. The multivariate analysis of variance and covariance indicated a statistically significant gender difference in favour of males concerning mathematics achievement, motivation to learn mathematics, and self-concept in mathematics. There was a preference for females regarding perceptions of teachers' instructional support. Similar to Espinoza and Taut (2020), Rodríguesz et al. (2020) investigated male and female

attitudes towards mathematics. The sample comprised 897 students (450 males, 447 females) in their 5th and 6th year of primary school. The results indicated that female students had less positive attitudes to mathematics than boys. However, there was no statistically significant difference in mathematics performance. The results from the regression analysis indicated the positive impact of perceived self-efficacy on mathematics performance and introduced factors such as the effect of achievement emotions on performance. When comparing the studies of Kyaruzi (2021) and Rodríguez et al. (2020), we can conclude that self-efficacy and a positive attitude to mathematics can influence mathematics performance. Other variables such as anxiety can also negatively affect mathematics performance. The study results from Rodríguez et al. (2020) also suggest that males could be negatively affected by anxiety levels even though they may be confident inabilities. In addition to the studies listed, studies by Aleksić et al. (2019), Henschel and Roick (2020), and Seo and Lee (2021) all concluded that anxiety negatively affected mathematics performance, especially for the male population.

It is without a doubt that gender differences and similarities in mathematics are popular topics of discussion. However, what is important from the literature review is consensus on the facts that exist. Although they may not be intrinsic biological gender differences as they relate to the mathematics development of males and females, they exist gender differences when variables such as self-efficacy, motivation, self-concept (attitudes), and anxiety account for some of the influential variables in gender differences. Therefore, it is a prerequisite that any policy or program developed to assist students must include mechanisms to assist them in developing their self-efficacy, motivating their interest, improving their self-concept, and reducing their anxiety levels in mathematics.

2.3.2 Critical Race Theory (CRT) and Male Performance in Mathematics

Critical Race Theory (CRT) and male performance in mathematics have been topics of discussion over the past ten years. There is no doubt that CRT acts as a foundational theory that explains the interaction and intersection of race, beliefs, and cultural practices. Moreover, when linked to the performance of males in mathematics, the literature recognizes its influence on Black male success in mathematics.

Berry et al. (2014) concluded that even reform in the education sector concerning mathematics teaching and learning was not beneficial to Black students. The study further suggested that even policy changes promoting the message of 'mathematics for all' simply fulfilled a policy requirement. Davis (2014) examined the experience of Black males in mathematics education, linking the experience to social factors such as the community, schools, and classroom conditions. The qualitative study concluded that social factors heavily influenced Black male students in middle school mathematics classes. This conclusion is consistent with factors in humanism learning theory concerning effectiveness and general philosophy. The finding is also consistent with social learning theory, where the environmental factors form part of the human factors.

Davis (2019) suggested that the implication of culturally relevant pedagogy should influence the curriculum. CRT influenced Black males' beliefs, cultural practices, and attitudes toward mathematics. Like Davis (2014), the study drew significant relevance to humanism learning theory through the general philosophy and effectiveness factors and social learning theory's environmental and behavioural factors. Goings et al. (2017) investigated the experiences of 17-year-old Black male college students from the United Kingdom. They were enrolled in a historically Black college and university (HBCUs) to determine the usefulness of pre-college

mentoring. The findings suggested that the students benefited most from one-on-one mentoring sessions, which allowed them to develop strategies to be successful. The findings were consistent with the influence of general philosophy and psychomotor development in the humanism learning theory and social learning theory's environmental and behavioural factors.

In another study by Davis et al. (2013), he posited that for Black males to benefit from the education system, especially in mathematics, the support must come from someone who identifies with that race. Therefore, in this study, Davis et al. (2013) documented and analyzed the experience of a Black male mathematics teacher attached to an urban school district. His experience mainly influenced his belief system, cultural practices, and community support. CRT's themes are prevalent as they link belief systems, cultural tradition, and community. This study laid the foundation for a follow-up study by Davis (2018), who interviewed three (3) Black male mathematics teachers, two (2) from African countries, and one (1) Black United States mathematics teacher. Their preparation and teaching experiences formed the basis of the interviews. Following a qualitative narrative approach, the findings suggest that policymakers need to expand conceptualization to attract mathematics teachers from other countries and implement policies that support Black males in mathematics. Similar to Davis (2018), Harris and Davis (2018) used a collective case study approach to document and analyze the experience of three (3) Black male mathematics teachers in what was considered a diverse school district that was part of the same race and gender mentoring program. The findings were consistent with CRT concerning the teacher identifying themselves as a minority with support needs in the mentoring program. The findings concluded that the mentoring program positively impacted their ability to execute their job function and offer support to Black male mathematics students.

While all of these studies reinforced the notion of CRT as a significant influence on the success of Black males in mathematics, Allen et al. (2018) highlighted that Black male student was still underserved. Every Student Succeeds Act (ESSA), that purported to be legislation that advocates for the success of Black male students, was still not manifested in the field. The study suggested that race, gender, and other forms of oppression in the teaching and learning system were still considered a constraint for Black male youths. Based on the study's recommendations, culturally grounded and social-justice-oriented perspectives are more prominent in the development of policy and, where possible, policy changes to meet the needs of Black male students. Concerning policy change and promoting more support for Black male students in mathematics, Davis and Jett (2019) highlighted that CRT should be more dominant in developing pedagogical frameworks to enhance mathematics education, especially for Black male students. These recommendations are in a study by Davis et al. (2019). The author suggests that Black male students benefit from specialized mathematics options in high school to gain the necessary knowledge to advance mathematics courses to transform their lives and communities. Similarly, Coleman and Davis (2020) noted that Black male students who received mentorship from Black male teachers significantly increased STEM-based academic efficacy. It allowed for increased use of transactional strategies to be implemented in teaching and learning mathematics through better teacher-student relationships.

One cannot dispute that the increased awareness of CRT in mathematics education has allowed for better teaching and learning in mathematics education in general. Throughout this subsection, the findings and results indicate that humanism learning theory and social learning theory are interlinked with the success of Black male students in mathematics at all levels and should form part of the foundation for designing educational policy and programs.

2.3.3 Supporting Black Male Students in Mathematics

The constant theme of supportive mechanisms and structures to influence success in mathematics, especially for the Black male population, is highlighted throughout the literature. In a study by Bowen (2018), the author noted that the relationship between grit and Black males' enrollment in remedial mathematics courses is essential to succeed in higher-level mathematics. The theoretical framework, which centers around the concept of grit, is considered a non-cognitive/behavioural factor that is an element linked to perseverance which is one of the major driving factors that influence course grades in the remedial course. The study concluded that the correlation between grit and final course grade was positive, indicating that grit positively influences course outcomes.

Apart from identifying grit as a factor captured in the humanism learning theory under the effectiveness factor and the behavioural factor in the social learning theory, Coleman (2016) addressed the issue of motivation. Coleman (2016) noted that five (5) significant factors influenced gifted and talented Black male students in science, technology, engineering, and mathematics (STEM). Those factors are 1) the field is progressive, 2) there is learning and discovery of knowledge, 3) there is problem-solving that advances humanity, 4) it allows for improvement in the Black community, and 5) there is money in the field. Tying back these factors to the system hybridism learning theory, progressiveness can be linked to the effectiveness factor in the humanism learning theory and the behavioural factors in the social learning theory. For the learning and discovery of knowledge, this can be linked to the cognitive development in the humanism learning theory and the cognitive factors in the social learning theory which influence the overall process of improving mathematics performance. In addition, the factors that relate to the problem solving that advance humanity and improve the Black

community can be linked to the general philosophy in the humanism learning theory and the behavioural factors in the social learning theory.

Based on the literature, most studies on those factors influencing mathematics success were quantitative. However, to broaden the scope of the literature review process and identify other possible methods that can affect success, Qaqish (2018) used a qualitative narrative study approach that examined pathways, racial identities, and mathematical identities of the experiences of Black male engineering students. Although the group captured in this study are engineering students, due to the mathematical content in engineering programs, the study still informs significant factors that influence success in mathematics. Qaqish (2018) addressed three (3) major research questions: 1) What are the experiences of Black male engineering students who transfer from community colleges to four-year institutions? 2) How do personal, social, and environmental factors shape the transfer experiences of Black male engineering students who attend four-year institutions? and 3) How do racial and mathematical identities shape the transfer experiences of Black male engineering students who attend four-year institutions? In conclusion, Black male students' identity awareness evolves as they develop their engineering identity based on their mathematics experience at the middle and high school level. In addition, their overall academic and social experiences form part of their socialization, eventually influencing their outlook on engineering and mathematics. One can also conclude that the availability of mentorship around engineering from the community assists in solving complex problems and further developing positive racial and mathematical identities. Linking these conclusions to the stated learning theories, identity awareness evolution is an element of general philosophy in humanism learning theory and behavioural factors are elements in social learning theory. Socialization and mathematical identities also forms part of the general philosophy and

effectiveness factors in humanism learning theory while the environmental and behavioural factors in forms part of the social learning theory.

Bramlett and Herron (2005) examined factors that affect students' attitudes towards mathematics. The population selected for the study was African American males and females. Nine (9) of the Fennema-Sherman Mathematics Attitude Scales were the basis of measurement in a college algebra class in an urban public institution. The scales used to measure the students' attitudes were the Attitude Toward Success in Mathematics Scale (AS), The Mathematics as a Male Domain Scale (MD), The Mother Scale (M), The Father Scale (F), The Teacher Scale (T), The Confidence in Learning Mathematics Scale (C), The Mathematics Anxiety Scale (A), The Effectance Motivation Scale in Mathematics (F), and The Mathematics Usefulness Scale (U). According to Bramlett and Herron (2005), based on the multiple linear regression analysis results, 15.3% of student achievement was explained by the domain scale, where confidence was the most impactful. In addition, the male domain, father domain, and confidence domain scores were statistically significantly different when compared between gender. The results, especially noting that the father domain and confidence domain are high-impact variables, logically follow that the support of a father concerning their son positively influences Black male student performance in mathematics.

McGee and Pearman (2015) and McGee and Pearman (2014) investigated the risk of talented Black male students' mathematics success linked to their social, racial, and gender identities. Through narrative analysis, they used semi-structured interviews to investigate how internal protective and risk factors operated in their lives. The results suggested that the thirteen (13) males interviewed identified beliefs, practices, coping strategies, and a positive attitude that assisted in forming a positive mathematical identity. McGee and Pearman (2014) went a little

further in their investigation by using the phenomenological variant of ecological systems theory (PVEST) to explore the different stages of risk. It included identity dynamics, situational risk, and protective factors (internal and external) to understand how talented Black males operate and negotiate to succeed in and outside the classroom. Males' beliefs, practices, and coping strategies were significant factors that influenced success in mathematics. Varying risk factors identified, such as identity dynamics, situational risk, and protective factors, are all elements of humanism learning theory and social learning theory. Factors such as beliefs and practices form part of the elements in the general philosophy aspect that form part of the whole-body factor.

Allen (2014) examined the effects of early academic consulting on freshman college mathematics placement for credit and non-credit courses. Using a quasi-experimental research design, one group of participants included eighteen (18) African American male high school graduates who took algebra 2 in grade 9. The comparison group was thirty-five (35) African American male graduates who took algebra 2 in grade 11. The results from (Allen, 2014) indicated that students who took algebra in grade 9 were placed in for-credit mathematics courses at the college level more frequently than those who algebra in grade 11. The results suggest that the earlier students take algebra, the higher the likelihood of taking a for-credit college-level course. Students that took algebra in grade 9 exhibited higher self-regulation skills which were determined to be an influential variable that led to higher success rates in mathematics.

Supporting Black male students in mathematics has been advocated for over ten years. The literature in this study further makes the case that policy must align with intended outcomes. However, the examination and analysis of the literature have shown, in some cases, an apparent disconnect between intended results and policy implementation, especially concerning the

Caribbean Region. Therefore, this study seeks to narrow that gap by providing evidence to support policy change decisions and, where possible, developing policies that increase the likelihood of students performing at their optimal in mathematics.

2.4 Summary

The purpose of the literature review was to examine pertinent research that assisted in answering the research questions. We divided the literature into three (3) subtopics: 1) Gender Similarities and Differences in Mathematical Development, 2) Critical Race Theory (CRT) and Male Performance in Mathematics, and 3) Supporting Black Male Students in Mathematics. The literature was clear about what is needed to improve student mathematics performance. It was a combination of identifying the differences and similarities between males and females to assist them in developing their self-efficacy, motivating their interest, improving their self-concept, and reducing their levels of anxiety in mathematics. The literature also recognized the need to increase awareness of CRT in mathematics education as it allows for better teaching and learning in mathematics education. Finally, concerning supporting Black male students in mathematics, the literature in this study further makes the case that policy must align with the intended outcomes.

The examination and analysis of the literature have shown, in some cases, an apparent disconnect between intended outcomes and policy implementation, especially concerning the Caribbean Region. Therefore, one may conclude that there must be a balanced approach to policy implementation and execution between theoretical structures and practice. There is enough evidence to suggest that there is an interlinkage between humanism learning theory and

social learning theory which directly influences the success of Black male students in mathematics at all levels.

The next chapter will present the research methodology and procedures used in this study. In addition, there is discussion around the following areas; type of research, data collection, and data analysis.

Chapter 3—Methodology

3.1 Introduction

This quantitative study investigates if males who take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination have a statistically significantly higher average score than those who only take the CSEC mathematics examination. In addition, the study also proposed statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant gender difference between average female and average male scores on the CSEC mathematics examination for those between 14 and 19 years old. Two research questions guided this study. This chapter restates the research questions and hypotheses, along with a detailed description of the step-by-step methodological process.

3.2 Research Questions

The following research questions (RQ) and hypotheses (H) guided the dissertation and met the objectives of the research:

RQ_1: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?

RQ_2: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC)

examination result in a statistically insignificant difference between the average female and average male scores on the CSEC mathematics examination?

$H_{1\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will not be a statistically significant increase in the average score.

$H_{1\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will be a statistically significant increase in the average score

$H_{2\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically insignificant difference between the average female and average male scores.

$H_{2\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically significant difference between the average female and average male scores.

3.3 Research Methodology and Design

This study used a cross-sectional quasi-experimental quantitative design in collecting and analyzing data from a secondary data source. The design used subject variables (examination performance scores) from male and female candidates. The design used was appropriate since it allowed for the comparison between male and female ages 14-19 examination scores between 2018 and 2020. I compared the male cohort group who completed the CCSLC mathematics examination before the CSEC mathematics examination to the cohort group who only completed

the CSEC mathematics examination. I also compared the male and female cohort groups who completed the CCSLC mathematics examination before the CSEC mathematics examination.

3.4 Research Setting/Context

The Caribbean Secondary Education Certificate (CSEC) mathematics examination has presented many challenges to students concerning low average scores. More directly, male performance on the examination is statistically significantly lower when compared to female performance. The average normalized score (**/100) for all males (1,418) in the representative sample between the age of 14 and 19 across all territories registered for the examination in the Caribbean between 2018 and 2020 that wrote the CSEC mathematics examination without writing the CCSLC mathematics examination was 34.54. The normalized average score for females who wrote the CCSLC mathematics examination before the CSEC mathematics examination was 35.78. To conduct further statistical analysis, 4,667 candidates from the total population allowed for an acceptable representative sample.

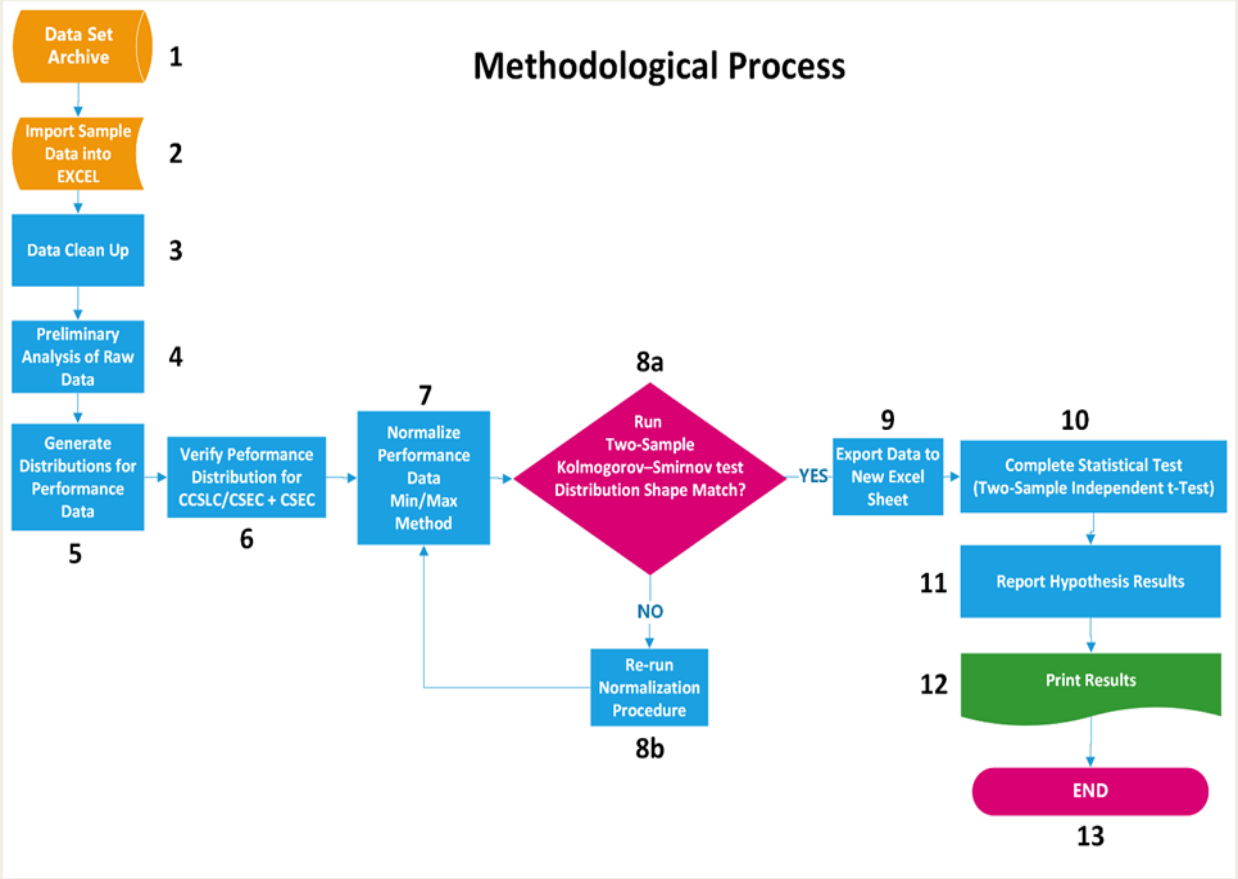
Although the scores may appear comparable, the average male performance is below the average score in CSEC and CCSLC/CSEC mathematics across the population (Caribbean Examinations Council, 2022). This study proposes to present enough statistical evidence to merit an educational policy change. In addition, the literature is clear about the need to offer support programs across the Caribbean region to improve the overall performance of the total population. Within the context of this study, a particular focus on the male population is presented as a case to support the mandatory implementation of students taking the CCSLC mathematics examination before the CSEC mathematics examination.

3.5 Research Sample and Data Sources

The steps in the methodology with respect to data sources and data sampling are defined and described in this section below. All steps of the complete methodological process are in Figure 3-1. In addition, a detailed description of the 13 steps in the entire methodological process is in the subsection below, including study procedures and data analysis.

Figure 3-1.

Methodological Process (Griffith, 2022b)



3.5.1 Data Set Archive (SQL/Excel Linked Connection)

The data set archive was in the data warehouse of the Caribbean Examinations Council (CXC). The data extraction process required using a structured query language (SQL) query code captured in Appendix A. For security purposes, there was some redaction of some of the code. The fields extracted from the database were: Age, Gender, CCSLC Session, Subject Code, CCSLC Subject, CCSLC Grade, CCSLC Final Mark, Candidate Number (Anonymized), CSEC Session, CSEC Subject Code, CSEC Grade, and CSEC Final Mark.

3.5.2 Import Sample Data into Excel

The data queried within the SQL/Excel Linked Connection file was exported to a separate excel sheet and disconnected from the CXC database. The sampling method used was the weighted random sampling algorithm by territory (without replacement) based on Wong and Easton (1980). Their research explained how to partition the different populations of the territories by using the probability of selection linked directly to the fractional size of the finite population. As for using SQL to generate the required sample, Xu et al. (2008) explained how to generate the random sample without replacement using the sample size required and the group by function within the SQL console. The data sampled comprised students 14 – 19 years old, male and female, from all participating territories in the Caribbean Region. The weighted random sampling algorithm by territory was the most appropriate sampling method since population size varied by territory, gender, and age range. The sample size required was determined using the statistical power test in XLSTAT, Addinsoft (2022) with a 95% confidence interval and a 5% margin of error. Based on a population size of 460,000 subject entries per relevant examination session over three years, the minimum required sample was 384 per year. For completeness, 4,667 students were selected as the representative sample.

3.5.3 Data Clean-Up

The procedure used to clean the data followed Mayfield et al. (2009), who used the SQL functions SELECT, FROM, and GROUP BY to extract the data to be cleaned. Following completion of the data extraction process, cleaning the data required using conditional statements to meet the criteria for Age, Gender, CCSLC Session, Subject Code, CCSLC Subject, CCSLC Grade, CCSLC Final Mark, Candidate Number (Anonymized), CSEC Session, CSEC Subject Code, CSEC Grade, and CSEC Final Mark. Using pseudo-language to explain the conditionals/filters applied in SQL were age between 14 and 19, gender (male, female), examination sessions between 2018 and 2020 for all examinations, and subject code (mathematics). This procedure required an identical SQL query to ensure that the results produced were the same structure as the original results. After applying additional conditionals/filters to remove students who received a grade of absent (X) or ungraded (UNG) from either the CCSLC or CSEC examination, the data set included 4,293 students instead of 4,667.

3.5.4 Preliminary Analysis of Raw Data

The analysis completed was similar to Manju and Mathur (2015), where the data collected was summarized using univariate analysis. This type of analysis describes, "…the distribution of a single variable, including its central tendency (including the mean, median, and mode) and dispersion (including data-set, and measures of spread such as the variance and standard deviation)" (Manju and Mathur, 2015, p. 1189). Using this method of analysis during this step of the methodological process allowed for the generation of basic descriptive educational measurement statistics. Using the descriptive statistics function in XLSTAT, the

statistics generated were the mean, minimum, maximum, standard deviation, variance, skewness, range, kurtosis, and p-p plots.

3.5.5 Generate Distribution for Performance Data

I generated the statistical distributions for student samples who wrote the CCSLC mathematics examination before the CSEC mathematics examination and those who only wrote the CSEC mathematics examination. The distribution fitting module from XLSTAT allowed me to complete this step.

3.5.6 Verify Performance Distribution for CCSLC/CSEC and CSEC

The performance distribution verification process required using a cross-reference sample from the CXC database linked to the original excel file to test for normality. I completed the Shapiro-Wilk normality test using XLSTAT following the procedure outlined in Shapiro and Wilk (2015).

3.5.7 Normalize Performance Data

Similar to Ioffe and Szegedy (2015), implementing a batch normalization algorithm allowed for the reduction in the processing time and minimization of possible errors in the normalized data. I implemented this algorithm to rescale the CCSLC and CSEC data points due to their difference in score ranges. The data were normalized using the transformation, rescaling the min-max normalization function in XLSTAT.

3.5.8 Distribution Matching

After the normalization process, I completed the process of distribution matching using the original and new normalized distributions. To verify that the distributions met the matching criteria, I completed the Kolmogorov–Smirnov test XLSTAT as outlined in Fasano and Franceschini (1987) and Xiao (2017) to ensure that the statistical qualities did not differ even though central tendencies measures changed. Maintaining the shape of the distribution after normalization is of greater importance which can be verified using the probability-probability (P-P) plots along with the two-tailed Kolmogorov-Smirnov test plots.

3.5.9 Export Data to New Excel Sheet

This step was necessary to maintain computational power, as Microsoft (2022) recommended. The machine used in this study was a LENOVO MT 20MF BU Think FM ThinkPad X1 Extreme with an Intel (R) Core (TM) i7-8750H CPU @ 2.20GHz, 2208 MHz, 6 Core(s), 12 Logical Processor(s), Microsoft Windows 10 Pro operating system, Installed Physical Memory (RAM)32.0 GB and 475.69 GB (510,770,802,688 bytes) SSD.

3.5.10 Complete Statistical Test/Data Analysis

I completed an independent two-sample t-Test to test the hypotheses and answer the research questions to determine if the average scores for male candidates were statistically significantly higher if the CCSLC mathematics examination was taken before the CSEC mathematics examination and if male and female scores were comparable if males wrote the CCSLC mathematics examination before the CSEC mathematics examination. The two samples were performance data for students who wrote the CCSLC mathematics examination before the

CSEC mathematics examinations and those who only wrote the CSEC mathematics examination. The guiding research questions were:

RQ_1: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?

RQ_2: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) examination result in a statistically insignificant difference between the average female and average male scores on the CSEC mathematics examination?

3.5.11 Report Hypotheses Results

The report of the results is below from step 10 based on the two (2) hypotheses:

$H_{1\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will not be a statistically significant increase in the average score.

$H_{1\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will be a statistically significant increase in the average score

$H_{2\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically insignificant difference between the average female and male scores.

$H_{2\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically significant difference between the average female and male scores.

3.5.12 Print Results

The results were posted in chapter four, with further discussion of results in chapter 5, covering the implications, recommendations, and conclusion.

3.5.13 End

The methodological algorithm terminated.

3.4 Ethical Assurances

The anonymization of the student examination performance data used in this study from the source followed all guidelines of the Institutional Research Board (IRB) at Gwynedd Mercy University. The only identifying data in the data set were gender and age. No other identifying was present; therefore, the loss of confidentiality was minimal and no more than exposure in daily life. The dataset was kept on a password-protected laptop. The researcher and dissertation committee chair had access to the data set. The data garnered from this study will be kept secure, and the results will be presented to a professional body to meet the dissemination requirement for graduation. Before collecting data, the researcher received notification in writing of exempt status from the IRB of Gwynedd Mercy University. The researcher also completed the required Collaborative Institutional Training Institute (CITI) training.

Chapter 4—Results

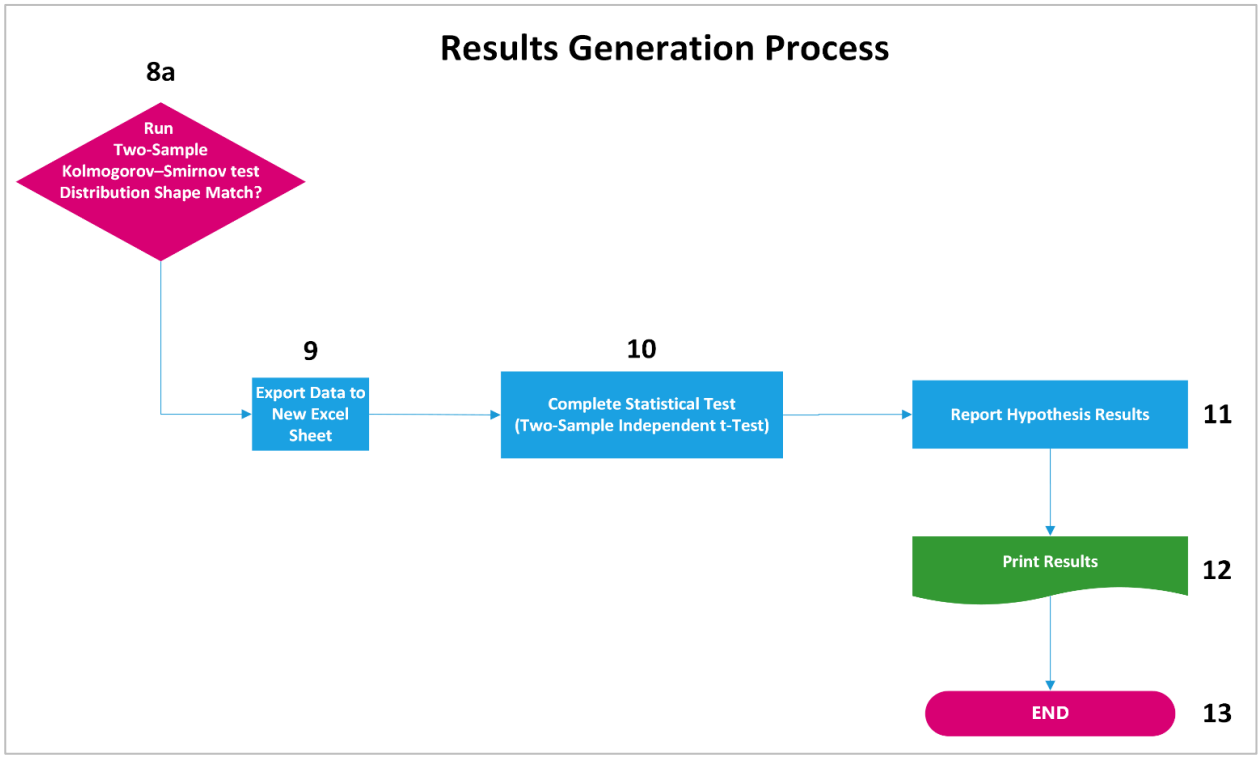
4.1 Introduction

This chapter presents the results of the study. The purpose of this quantitative study was to provide statistical evidence to support that males who take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the CSEC mathematics examination have a statistically significantly higher average score than those who only take the Caribbean Secondary Education Certificate (CSEC) mathematics examination. In addition, the study provides statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant gender difference between female and male average scores on the CSEC mathematics examination for those between 14 and 19 years old.

The chapter begins with the introduction and then examines the validity and reliability analysis of the dataset. In addition, the description of the data and the preliminary results of the validation methods follows. After this, I link the results to the two research questions and present the hypotheses results using tables and figures from the independent two-sample t-test. All steps taken in generating the results (steps 8a - 13) are captured in Figure 4-1, the results generation process. Finally, the data of the study is summarized to end this chapter.

Figure 4-1.

Results Generation Process (Griffith, 2022c)



4.2 Validity and Reliability of the Data

The methods used to validate the data were the statistical power test for sampling selection (Efraimidis, 2015). I completed the two-sampled Kolmogorov–Smirnov (KS) test Fasano and Franceschini (1987) and Xiao (2017) to compare the distributions. I also used the Shapiro–Wilk test for normality (Shapiro and Wilk, 2015). In addition, I employed the use of descriptive statistics to identify the level of skewness and kurtosis of the distribution to ensure that there was no excessive clustering on the tails of the performance data distribution. The results from the reliability and validation tests performed are present in Figure C1 to Figure C6

and in Table C1 to Table C3. The post-results statistical cross-validation[1] to validate the study results is in Appendix D[2].

The sampling method used was the weighted random sampling algorithm by territory (without replacement) based on Wong and Easton (1980). Their research explained how to partition the different populations of the territories by using the probability of selection linked directly to the fractional size of the finite population. The data sampled comprised students 14 – 19 years old, male and female, from all participating territories in the Caribbean Region. The weighted random sampling algorithm was the most appropriate sampling method since multiple territories had varying population sizes, gender, and age ranges. The sample size required was determined using a power analysis test in XLSTAT with a 95% confidence interval and a 5% margin of error. Based on a population size of 460,000 subject entries per relevant examination session over a three-year interval, the minimum required samples were 384 per year. For completeness, I selected 4,293 students for the sample after data clean-up. The calculation methods used to generate the values are in Figures B1 and B2.

After the generation of the sample, I completed the two-sampled Kolmogorov–Smirnov (KS) test to ensure that the original and normalized distributions maintained their shape for both CCSLC, CCSLC/CSEC, and CSEC only distributions, as seen in Figures C1 to C6. In addition, I completed the Pearson correlation test, which resulted in an acceptable positive correlation between the two distributions, as seen in Tables C1 to C3.

[1] Steps 8a to 13 were repeated using a random sample based on the mean and standard deviation of the original distributions with an aim of showing that the results can be generalized to another similar sample with the same distribution characteristics.

[2] Due to the large size (N=4293, 59 pages) of the data set used throughout the cross-validation process, it may be accessed via https://drive.google.com/file/d/1jEf_L6cKtVzJSu8Ida4acOXQjOChON-0/view?usp=sharing

4.3 Results

This study explores the performance of males and females on the CSEC mathematics examination. The research attempted to capture the results of those male students who completed the CCSLC mathematics examination before the CSEC mathematics examination and those students who only wrote the CSEC examination. The study aimed to answer two research questions about male performance in mathematics and the gender difference between males and females on the CSEC mathematics examination. The entire sample consisted of 4,293 students between the ages of 14 and 19, male and female, after the data clean-up procedure. The minimum number of students required for the study to be statistically significant was 384. Depending on the test completed, the number of students sampled was between 1418 and 4,293.

I used the independent two-sample t-test to test the statistical significance between mean scores for male students who completed the CCSLC mathematics examination before the CSEC mathematics examination and those students who only wrote the CSEC examination. In addition, I used the independent two-sample t-test to determine if there was a statistically significant difference between male and female mean scores on the CSEC mathematics examination.

Table C4 presents the descriptive results for male students who wrote the CCSLC mathematics examination before the CSEC mathematics examination with a mean score (M = 36.26, SD = 15.69) in comparison to male students who only wrote the CSEC mathematics examination with (M =34.54, SD = 14.58). Table C5 presents the comparison between males who wrote the CCSLC mathematics examination before the CSEC mathematics examination with a mean score (M = 36.26, SD = 15.69) based on 1,817 observations in comparison to the female students that wrote the CCSLC mathematics examination before CSEC mathematics examination with a score (M = 35.78, SD = 15.82) based on 2,476 observations.

4.4 Research Question 1/Hypothesis 1

RQ_1: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?

The study investigated Research Question 1 using descriptive statistics, including the means and standard deviations. The mean of each performance distribution was analyzed and reported in Table C4. The CCSLC/CSEC performance data indicated that males' average scores increased. An independent two-sample t-test for statistical significance was completed which indicated that the CCSLC/CSEC group when compared to the CSEC only group mean scores were statistically significantly greater, $t(3136.979) = 3.226$, $p = .001$, $d = 1.723$, 95% CI [0.844, +Inf]. The results of the test presented in Table C6 and Figure C7 suggest rejecting the null hypothesis and accepting the alternative hypothesis.

4.5 Research Question 2/Hypothesis 2

RQ_2: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) examination result in a statistical insignificance of gender difference between the female and average male scores on the CSEC mathematics examination?

The study investigated Research Question 2 using descriptive statistics, including the means and standard deviations. The mean scores of each performance distribution were analyzed and reported in Table C5. The mean scores between CCSLC/CSEC males and CCSLC/CSEC females were comparable and did not present any statistically significant mean score differences,

$t(3931.002) = 0.995$, $p = .320$, $d = 0.484$, 95% CI [-0.470, 1.438]. The results of the test presented in Table C7 and Figure C8 suggest that the null hypothesis not be rejected.

4.6 Summary of Results

Two research questions guided the results of this study. First, this research attempted to investigate the impact of male students taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before taking the more advanced Caribbean Secondary Education Certificate (CSEC) mathematics examination when compared to other male students that did not take the CCSLC mathematics examination before taking the CSEC mathematics examination. Second, the study explored the effects of male students taking the CCSLC mathematics examinations before the CSEC mathematics examination compared to female students who took the CCSLC examination before the CSEC examination. The study sampled 4,293 male and female students between 14 and 19 years old from May/June 2018-2020 examination sessions.

The results indicated that male students who took the CCSLC mathematics examination before the CSEC mathematics examination received a statistically significantly higher mean score than their male counterparts who only took the CSEC mathematics examination based on the two-sampled independent t-test. Secondly, when compared to female students who wrote the CCSLC mathematics examination before taking the CSEC mathematics examination, the results showed that the male students' mean score was marginally higher than the female student. Although the male students' score was marginally higher than the female student, based on the two-sampled independent t-test, there was no statistically significant difference in the mean scores, making them comparable.

Chapter 5—Implications, Recommendations, and Conclusions

This chapter begins with an overview of the entire study, followed by a summary of the research results for each research question. Next, the chapter discusses the implications based on the research study results. It is followed by comparing the results to the existing body of research in the literature while adding to the body of knowledge from a Caribbean perspective and evidence-based policy focus. Finally, the chapter will conclude with recommendations for practice and future research.

5.1 Summary of the Study

Critical theoretical concepts such as applying humanism learning theory and social learning theory are central to improving and increasing sustainable student learning and development in general. The mediating process between stimuli and responses as a basis of learning from the environment through the process of observation, as highlighted in social learning theory, forms another foundation for learning. More directly, Gonzalez et al. (2020) further explain that identifying the group of learners as marginalized due to race and community affiliation is an essential step in learning mathematics. Apart from social learning theory as a primary foundation for learning, Qadry et al. (2021) explored humanism learning theory as another foundation since the best learning occurs when the whole person, including the cognitive, affective, and psychomotor, is involved. Since humanism learning theory has a foundation based on the general philosophy surrounding values, religion, culture, and ideology that inform the learning process, we can link this to the development of mathematics education.

The current research recognizes the need for more practical approaches to designing educational policy and support mechanisms that significantly impact marginalized groups. Designing policies should treat the immediate needs of the different learning groups, in our case,

students between 14 and 19 years old that need assistance in improving their performance in mathematics. Therefore, a more practical proposition is to combine critical theoretical concepts such as humanism learning theory and social learning theory to increase the likelihood of students improving their performance in mathematics. To make the linkages between other learning theories and, more directly, social learning theory and humanism learning theory, I introduced the concept of a system hybridism learning theory (SHLT) as a working theory that can combine social learning theory and humanism learning theory into a conceptual framework.

As identified in SHLT, educational policy changes must be the central and driving change agent to improve the likelihood of students improving their performance in mathematics. More directly, male students should have access to major support programs that cater to their needs. This study aimed to provide enough statistical evidence to support a change in educational policy in the Caribbean Region, making it mandatory for students to take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination.

The purpose of this quantitative study was to provide statistical evidence to support that if males take the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination have a statistically significantly higher average score than those who only take the CSEC mathematics examination. In addition, the study also proposed statistical evidence to support that if males take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant difference between female and male average scores on the CSEC mathematics examination for those between 14 and 19 years old. Previous studies identified the need for male students to be exposed to better support systems in the study

of mathematics to perform optimally on high stake examinations. With respect to research question one, the results indicated that male students who wrote the CCSLC mathematics examination before the CSEC mathematics examination received a statistically significantly higher mean score than their male counterparts who only took the CSEC mathematics examination. With respect to research question two, when compared to female students who wrote the CCSLC mathematics examination before taking the CSEC mathematics examination, the results indicated that the male students who wrote the CCSLC mathematics examination before the CSEC mathematics examination mean score was marginally higher than the female student. However, although the male students' score was marginally higher than the female student, based on the two-sampled independent t-test, there was no statistically significant difference in the mean scores.

5.2 Discussion

The guiding conceptual, theoretical framework, as seen in Figure 2-1, was used to draw relationships among the common themes of the literature to explain the concepts featured in the dissertation. The current literature sought to lay a foundation for establishing a basis for implementing a policy change that requires writing the CCSLC mathematics examination before the CSEC mathematics examination. The literature was very clear about what was needed to improve student mathematics performance; it was a combination of identifying the differences and similarities between males and females to assist them in developing their self-efficacy, motivating their interest, improving their self-concept, and reducing their levels of anxiety in mathematics. The literature also recognized the need to increase awareness of CRT in mathematics education as it allows for better teaching and learning in mathematics education.

Finally, concerning supporting male students in mathematics, the literature in this study further makes the case that policy must align with intended outcomes. The statistical evidence needed to justify a change in educational policy was required to present the case based on evidence rather than assumptions and hypothesized theses. The argument for this case's foundation is the fact that the examination and analysis of the literature have shown, in some cases, an apparent disconnect between the intended outcomes and policy implementation, especially concerning the Caribbean Region.

To bridge the gap between social learning theory and humanism learning theory, I introduced the idea of the system hybridism learning theory (SHLT). In order to identify and discuss the gaps in the literature, I used the process section of the theory since most of the explanations of the interactions among the student process factors and other factors exist in that section. Assuming that all sets and subsets in the process section of the theory are interdependent, mutually inclusive, and share continuous sequential probabilistic factors, the output (examination results), which is then attached to a feedback loop that influences the primary input variable, the student should be the motivation to implement policies that meet their immediate needs. To generate the statistical evidence needed to justify a change in educational policy, the following research questions (RQ) guided the study:

RQ_1: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?

RQ_2: Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC)

examination result in a statistical insignificance difference between the female and average male scores on the CSEC mathematics examination?

This study used a quantitative design in collecting and analyzing data from a secondary data source. First, I outlined the steps in the methodology in Figure 3-1. Second, I described the thirteen (13) steps in the entire process: the research setting/context, research sample and data sources, study procedures, and data analysis.

RQ_1: *Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) mathematics examination increase the average score of a male candidate statistically significantly?*

The study investigated **RQ_1** using descriptive statistics, including the means and standard deviations. The CCSLC/CSEC performance data indicated that males' average scores increased. An independent two-sample t-test for statistical significance was completed which indicated that the CCSLC/CSEC group when compared to the CSEC only group mean scores were statistically significantly greater, $t(3136.979) = 3.226$, $p = .001$, $d = 1.723$, 95% CI [0.844, +Inf]. The results of the test suggest rejecting the null hypothesis and accepting the alternative hypothesis.

$H_{1\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will not be a statistically significant increase in the average score.

$H_{1\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will be a statistically significant increase in the average score.

RQ_2: *Can taking the Caribbean Certificate of Secondary Level Competence (CCSLC) mathematics examination before the Caribbean Secondary Education Certificate (CSEC) examination result in a statistical insignificance difference between the female and average male scores on the CSEC mathematics examination?*

The study investigated **RQ_2** using descriptive statistics, including the means and standard deviations. The mean scores of each performance distribution were analyzed and reported in Table C5. The mean scores between CCSLC/CSEC males and CCSLC/CSEC females were comparable and did not present any statistically significant mean score differences, $t(3931.002) = 0.995$, $p = .320$, $d = 0.484$, 95% CI [-0.470, 1.438]. The results of the test suggest that the null hypothesis not be rejected.

$H_{2\text{-}0}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically insignificant difference between the average female and male scores.

$H_{2\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically significant difference between the average female and male scores.

We discuss the implications of the study's results in the next section of this chapter.

5.3 Implications

Research question one results reveal that the CCSLC/CSEC group performance data indicated that average male scores increased. Based on an independent two-sample t-test for statistical significance, the CCSLC/CSEC group, when compared to the CSEC only group, mean scores were statistically significantly greater. These results have implications at the policy level and mathematics program design level. At the policy level, the evidence suggests that it is beneficial for students to write the CCSLC mathematics examination before the CSEC mathematics examination as the likelihood of them getting a statistically significantly higher score on the CSEC mathematics examination increases. Therefore, there needs to be an educational policy change that makes it mandatory for students to write the CCSLC examination before the CSEC examination.

Research question two results reveal that the mean scores between CCSLC/CSEC males and CCSLC/CSEC females were comparable and did not present any statistically significant gender differences. Based on an independent two-sample t-test for statistical significance, the two groups' mean scores differences were statistically insignificant. It reiterates that if a policy change requires students to take the CCSLC mathematics examination before the CSEC mathematics examination, the likelihood of a male student receiving a comparable score with a female score increases.

Based on the literature review, this policy change would not only fill some of the gaps that exist in terms of developing and implementing a policy that has a direct impact on the group most needing it, but it also supports the process identified in the system hybridism learning theory known as policy change and implementation which forms part of the student experience process.

5.4 Recommendations for Practice

While this study would have created the conceptual framework and theory as identified in Figure 2-1 to integrate theory and practice, below are some of the recommendations for practice based on the literature analysis and results.

1. Revise educational policies with a focus on creating a positive impact on the most vulnerable groups.
2. Develop policies that ensure that educational institutions provide support to students of mathematics (Wilson-Akubude, 2017).
3. Integrate the notion of family and community support and learning in educational policy development (Coleman, 2016).
4. Use experienced professionals in their mathematical careers to mentor students who hope to pursue careers in mathematics (Harris and Davis, 2018).
5. Ensure that mathematics programs include mechanisms to assist them in developing their self-efficacy, motivating their interest, improving their self-concept, and reducing their levels of anxiety (Henry-Burrell, 2020).
6. In the Caribbean context, change the educational policy to make taking the CCSLC mathematics examination mandatory before the CSEC mathematics examination.

The recommendations listed above are all practical and should be implemented as soon as possible to reduce the learning gap in mathematics education.

5.5 Recommendations for Future Research

This quantitative study adds to the body of knowledge from a Caribbean perspective by providing statistical evidence to support the mandatory implementation of students taking the CCSLC mathematics examination before taking the CSEC mathematics examination. The study used a sample group of male and female students between 14 and 19 years old. The sample consisted of all participating territories in the Caribbean region. The recommendations for future studies are as follow:

1. Disaggregate the data used in the study to highlight territories rather than the Region.
2. Isolate mathematics performance data not only by the average score but by quartile ranges to investigate how different cohorts may perform.
3. Repeat the study but focus on the population older than 19 years old.
4. Develop a survey instrument to capture the Caribbean perspective on issues such as self-efficacy, motivation, self-concept (attitudes), and anxiety in mathematics education.

From completing this study, one may find that there are more questions than answers to issues affecting mathematics students. Therefore, this study should be a foundation for future researchers in areas such as evidenced-based educational development policy and mathematics education program design. It is for sure that policy heavily influences teaching and learning, especially at the middle and high school levels (Davis et al., 2019). This study also provides the foundation to explore System Hybridism Learning Theory which combines concepts of social learning theory and humanism learning theory along with student experience.

5.6 Conclusions

The results of this study based on statistical evidence indicate that if male students between the ages of 14 and 19 years old take the CCSLC mathematics examination before the CSEC mathematics examination, they will have a statistically significantly higher average score than those who only take the CSEC mathematics examination. Furthermore, evidence from the literature also indicates that the need for educational development policy changes that impact the group of learners that need the most support should be a priority. The statistical evidence from the tests completed also indicates that if male students take the CCSLC mathematics examination before the CSEC mathematics examination, there is a statistically insignificant difference between female and male average scores on the CSEC mathematics examination.

In conclusion, the results of the study have provided enough evidence to show the advantage of students and, more directly, males writing the CCSLC mathematics examination before the CSEC mathematics examination. Therefore, based on the statistical evidence, there should be a change in educational policy in the Caribbean Region that makes it mandatory for all students to take the CCSLC mathematics examination before taking the CSEC mathematics examination.

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Appendices

Appendix A: SQL Data Extraction and Sampling Code

```
select pr_national_code as '********', ro_facility_code
as'Centre',pr_second_names as *********,pr_first_names as
********',((DATEDIFF(DAY,pr_date_of_birth,cast(LEFT(ro_session,4) + '-08-
15' as smalldatetime)))/365)as Age, pr_sex as Gender, ro_session as
'****** Session', ro_subject_code as 'Subject Code',ro_syllabus_code as
'******* Subject', gr_grade as '***** Grade',ma_weighted_mark as '*****
Final Mark',v.candidateno as'***************', v.Session as '*****
Session',v.Subjectcode as'***** Subject Code',v.Subject as '**** Subject
Code',v.Grade as '***** Grade',v.FinalMark as '****** Final Mark'
from Vw********2 v,*****.dbo.*****,*****.dbo.roles
r,*******.dbo.*******,******.dbo.******
where p.pr_person_serial=r.ro_person_serial
and ro_session in (**********************)
and gr_grade_code like '%main%'
and ro_role_serial=gr_role_serial
and ro_subject_code in ('*****')
and RIGHT(rtrim(ro_subject_code),2)=RIGHT(rtrim(v.Subjectcode),2) collate
SQL_Latin1_General_CP1_CI_AS
and ro_role_serial=ma_role_serial
and ma_component_code='-'
and  (
pr_first_names=v.firstname collate SQL_Latin1_General_CP1_CI_AS
or left(pr_first_names,charindex(' ',pr_first_names)-1)=rtrim(v.firstname)
collate SQL_Latin1_General_CP1_CI_AS
)
and pr_second_names=v.lastname collate SQL_Latin1_General_CP1_CI_AS
and pr_sex=v.gender collate SQL_Latin1_General_CP1_CI_AS
and pr_date_of_birth=v.dob
order by ro_session,pr_second_names
SELECT m.Session, m.Territory, m.Candidateno as
****************',m.Gender, m.Subject, m.Subjectcode as 'Subject Code',
m.******, m.FinalMark as 'Final Mark'
FROM dbo.vw********2 m
where m.Session in ('**************')
and (abs(cast((binary_checksum(*)*rand()) as int)) % ***)<*.**
and m.Age between 14 and 19
and m.Subjectcode in ('***********')
and m.candidateno not in ('*****************')
)
and m.grade in (************)
group by m.Session, m.Territory, m.****, m.Gender, m.Subject,
m.SubjectCode, m.*********, m.*********
```

Appendix B: Sample Size Generation and Calculation

Figure B1.

Sample Size Generation

Finite population: $n' = \frac{n}{1+\frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2 N}}$

where
z is the z score
ε is the margin of error
N is the population size
p̂ is the population proportion

Figure B2.

Sample Size Calculation

$$n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2}$$

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384.16$$

Appendix C: Results of the Study

Figure C1.

P-P Plot CCSLC versus CCSLC Normalized Distribution 2018-2020

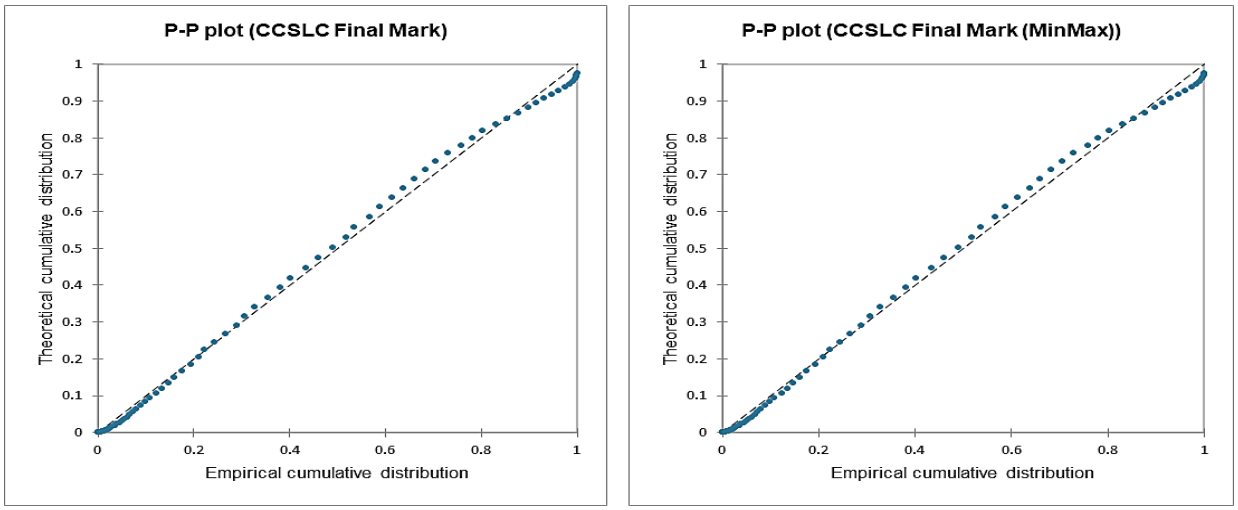
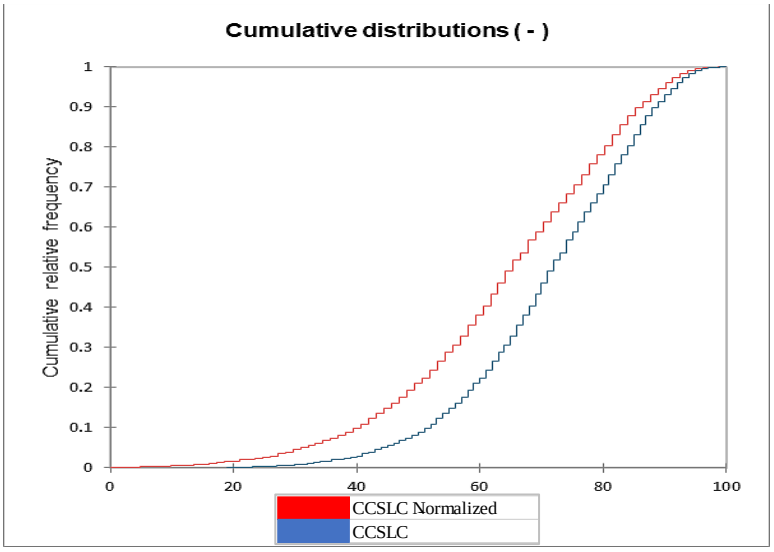


Figure C2.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CCSLC versus CCSLC Normalized Distribution 2018-2020[3]



[3]Ties have been detected in the data.

Figure C3.

P-P Plot CCSLC/CSEC versus CCSLC/CSEC Normalized Distribution 2018-2020

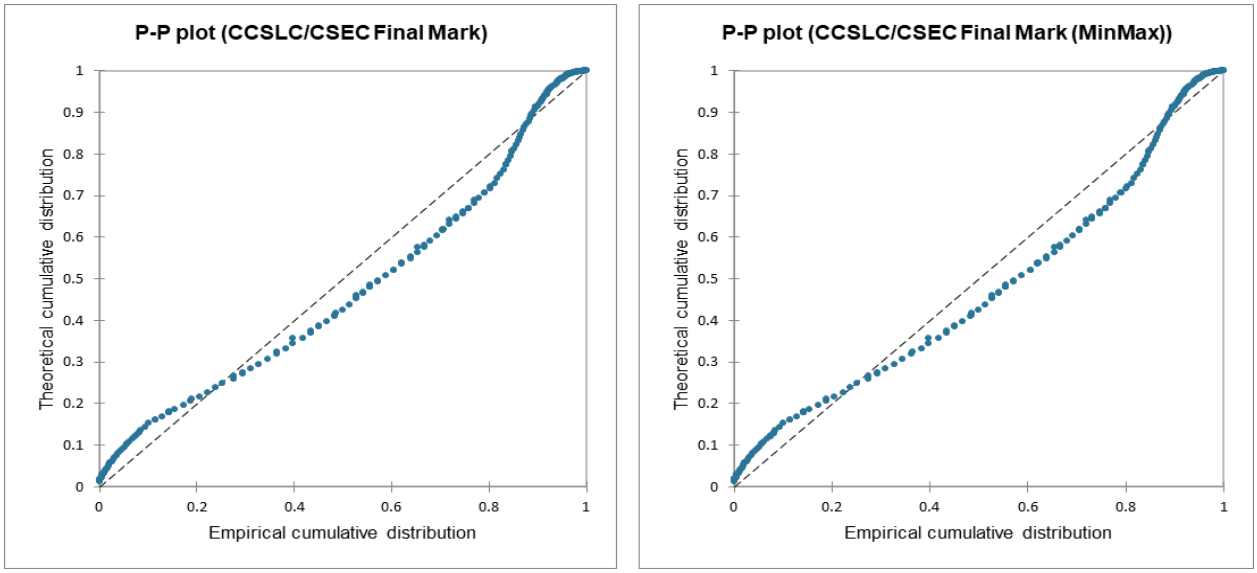
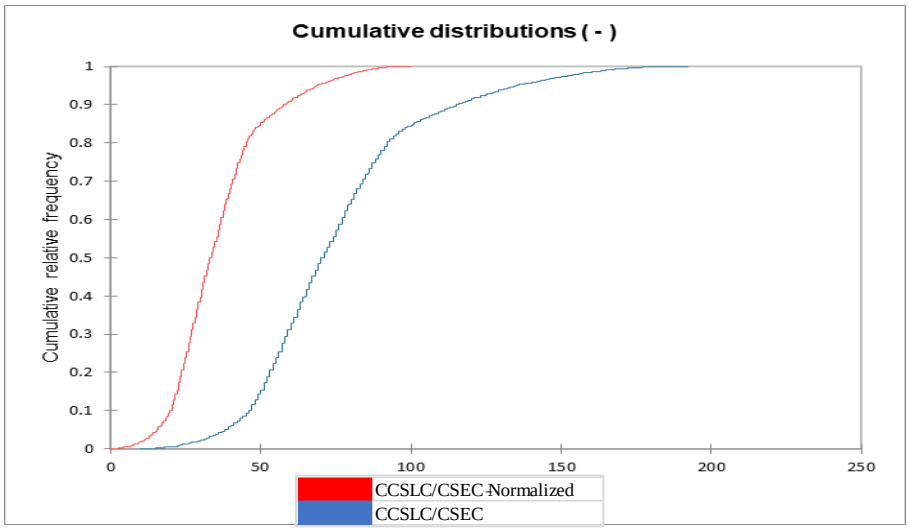


Figure C4.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CCSLC versus CCSLC Normalized Distribution 2018-2020[4]



[4]Ties have been detected in the data.

Figure C5.

P-P Plot CSEC Only versus CSEC Only Normalized Distribution 2018-2020

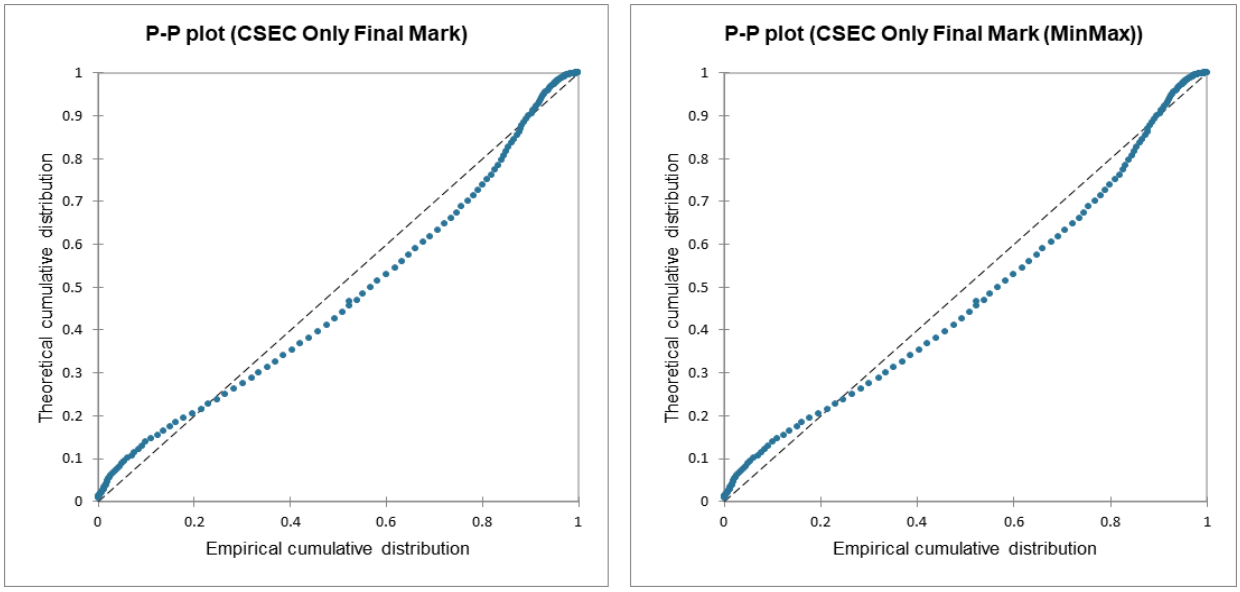
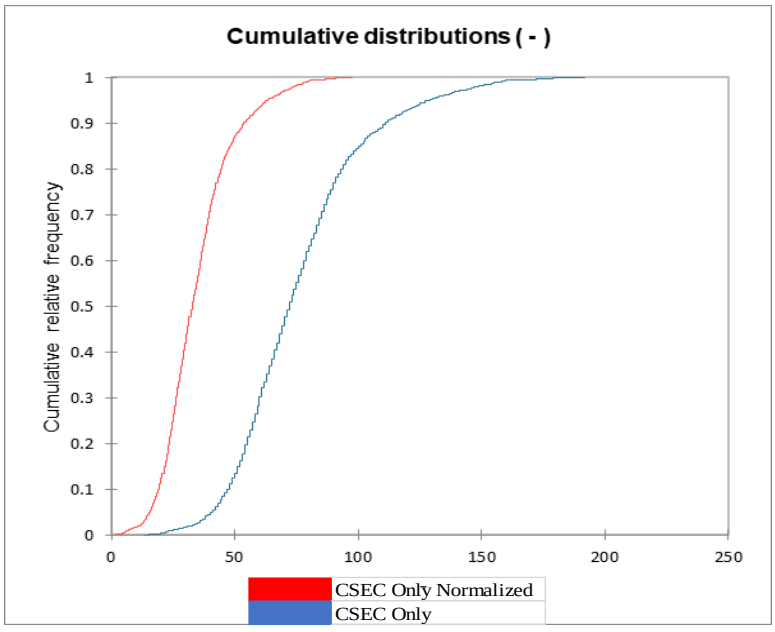


Figure C6.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CSEC Only versus CSEC Only Normalized Distribution 2018-2020[5]



[5]Ties have been detected in the data.

Table C1.

CCSLC versus CCSLC Normalized Descriptive Statistics and Correlation Test 2018-2020[6]

Summary statistics:							
Variable	Observations	Obs. with missing data	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC Final Mark	4293	0	4293	19.000	100.000	70.911	14.405
CCSLC Final Mark (MinMax)	4293	0	4293	0.000	100.000	64.088	17.784
Correlation matrix (Pearson):							
Variables	CCSLC Final Mark	CCSLC Final Mark					
CCSLC Final Mark	**1**	1.000					
CCSLC Final Mark (MinMax)	1.000	**1**					
Coefficients of determination (Pearson):							
Variables	CCSLC Final Mark	CCSLC Final Mark					
CCSLC Final Mark	**1**	1.000					
CCSLC Final Mark (MinMax)	1.000	**1**					

Table C2.

CCSLC/CSEC vs. CCSLC/CSEC Normalized Descriptive Statistics and Correlation Test 2018-2020[7]

Summary statistics:							
Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark	4293	0	4293	10.000	192.000	75.491	28.698
CCSLC/CSEC Final Mark (MinMax)	4293	0	4293	0.000	100.000	35.984	15.768
Correlation matrix (Pearson):							
Variables	CCSLC/CSEC Final Mark	CCSLC/CSEC Final Mark					
CCSLC/CSEC Final Mark	**1**	1.000					
CCSLC/CSEC Final Mark (MinMax)	1.000	**1**					
Coefficients of determination (Pearson):							
Variables	CCSLC/CSEC Final Mark	CCSLC/CSEC Final Mark					
CCSLC/CSEC Final Mark	**1**	1.000					
CCSLC/CSEC Final Mark (MinMax)	1.000	**1**					

[6] The Pearson correlation of approximately one between CCSLC versus CCSLC normalized distribution indicates that there is a strong positive relationship explained by their total positive linearity.

[7] The Pearson correlation of approximately one between CCSLC/CSEC versus CCSLC/CSEC normalized distribution indicates that there is a strong positive relationship explained by their total positive linearity.

Table C3.

CSEC Only vs. CSEC Only Normalized Descriptive Statistics and Correlation Test 2018-2020[8]

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
CSEC Only Final Mark	3314	0	3314	13.000	192.000	75.970	26.621
CSEC Only Final Mark (MinMax)	3314	0	3314	0.543	97.826	34.766	14.468

Correlation matrix (Pearson):

Variables	CSEC Only Final Mark	CSEC Only Final Mark (MinMax)
CSEC Only Final Mark	**1**	1.000
CSEC Only Final Mark (MinMax)	1.000	**1**

Coefficients of determination (Pearson):

Variables	CSEC Only Final Mark	CSEC Only Final Mark (MinMax)
CSEC Only Final Mark	**1**	1.000
CSEC Only Final Mark (MinMax)	1.000	**1**

Table C4.

CCSLC/CSEC Male vs. CSEC Only Male Descriptive Statistics 2018-2020

Summary statistics:

Variable	Observations	Obs. with missing	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax)/Male	1817	0	1817	0.000	100.000	36.263	15.693
CSEC Only Final Mark (MinMax)/Male	1418	0	1418	1.630	97.826	34.540	14.578

Table C5.

CCSLC/CSEC Male vs. CCSLC/CSEC Female Descriptive Statistics 2018-2020

Summary statistics:

Variable	Observations	Obs. with missing	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax)/Male	1817	0	1817	0.000	100.000	36.263	15.693
CCSLC/CSEC Final Mark (MinMax)/Female	2476	0	2476	1.648	97.802	35.779	15.823

[8] The Pearson correlation of approximately one between CSEC Only versus CSEC Only normalized distribution indicates that there is a strong positive relationship explained by their total positive linearity.

Table C6.

CCSLC/CSEC Male vs. CSEC Only Male Independent Two-Sample t-Test

t-test for two independent samples / Upper-tailed test:	
95% confidence interval on the difference between the means:	
[0.844, +Inf [	
Difference	1.723
t (Observed value)	3.226
t (Critical value)	1.645
DF	3136.979
p-value (one-tailed)	0.001
alpha	0.050
The number of degrees of freedom is approximated by the Welch-Satterthwaite formula	
The critical t is estimated using the Cochran-Cox approximation	
Test interpretation:	
H0: The difference between the means is equal to 0.	
Ha: The difference between the means is greater than 0.	
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.	

Figure C7.

CCSLC/CSEC Male vs. CSEC Only Male Independent two-sample t-Test Significant Increase in Male Average (Mean) Score

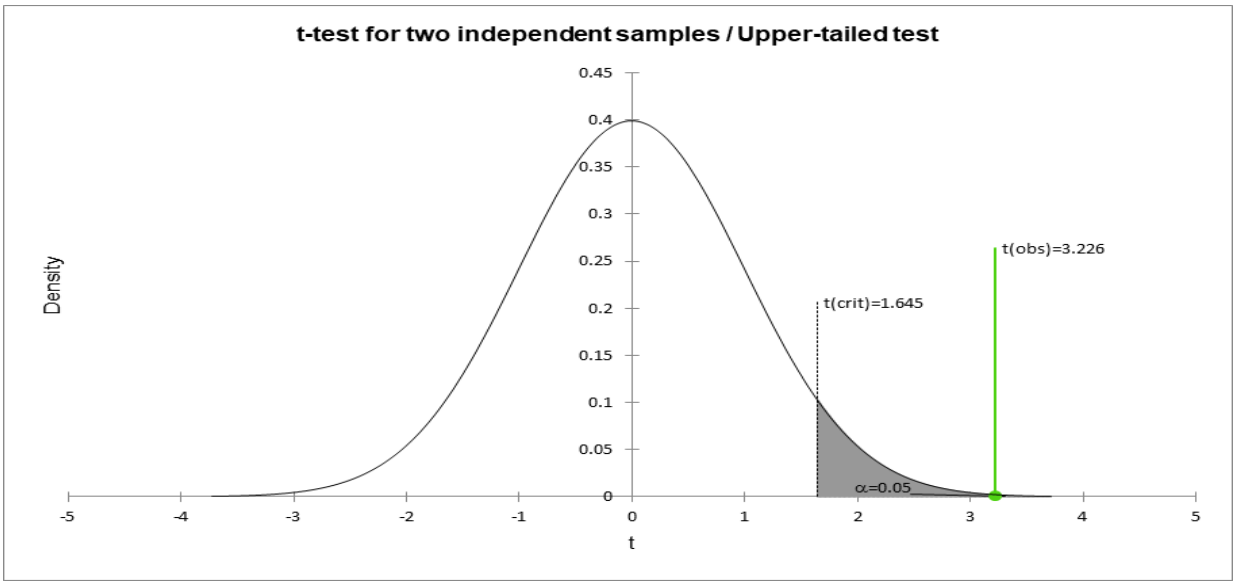


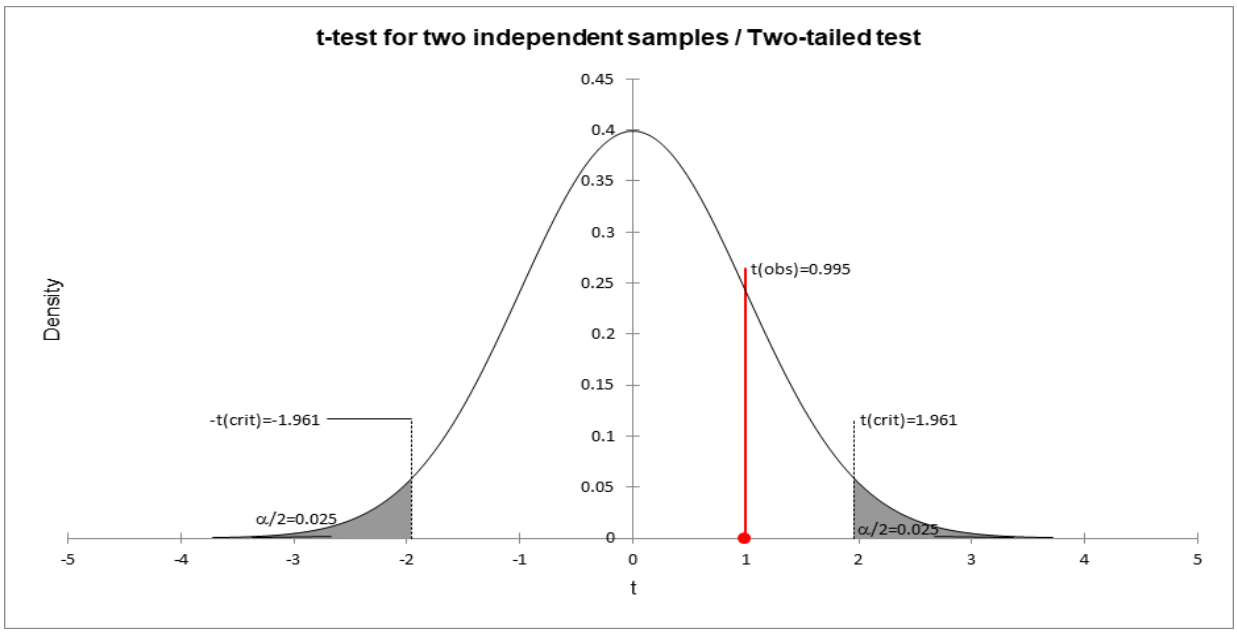
Table C7.

CCSLC/CSEC Male vs. CCSLC/CSEC Female Independent Two-Sample t-Test

t-test for two independent samples / Two-tailed test:	
95% confidence interval on the difference between the means:	
[-0.470, 1.438]	
Difference	0.484
t (Observed value)	0.995
|t| (Critical value)	1.961
DF	3931.002
p-value (Two-tailed)	0.320
alpha	0.050
The number of degrees of freedom is approximated by the Welch-Satterthwaite formula	
The critical t is estimated using the Cochran-Cox approximation	
Test interpretation:	
H0: The difference between the means is equal to 0.	
Ha: The difference between the means is different from 0.	
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.	

Figure C8.

CCSLC/CSEC Male vs. CCSLC/CSEC Female Independent two-sample t-Test Statistically Insignificant Gender Differences in Scores



Appendix D: Statistical Cross-Validation of Study Results

Table D1.

CCSLC/CSEC vs. CCSLC/CSEC Cross-Validation Kolmogorov-Smirnov Test

Summary statistics:

Variable	Observations	Obs. with missing	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax)	4293	0	4293	0.000	100.000	35.984	15.768
CCSLC/CSEC Final Mark (MinMax) Validation	1566	0	1566	0.000	94.505	35.999	15.955

Two-sample Kolmogorov-Smirnov test / Two-tailed test:

D	0.016
p-value (Two-tailed)	0.943
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation:

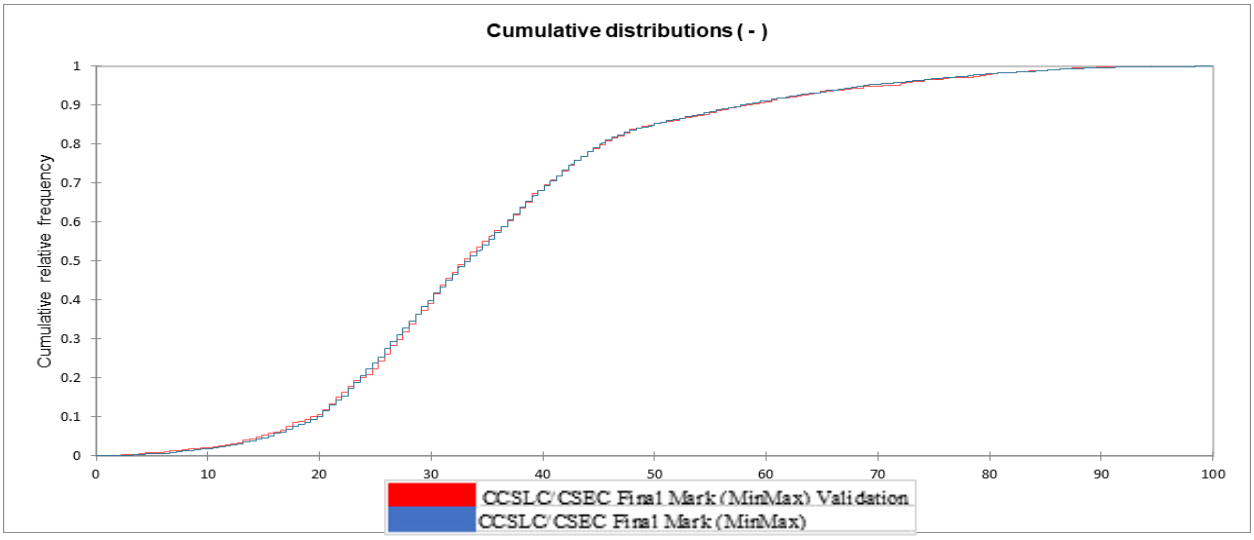
H0: The two samples follow the same distribution.

Ha: The distributions of the two samples are different.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Figure D1.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CCSLC/CSEC vs. CCSLC/CSEC Validation Distributions[9]



[9]Ties have been detected in the data.

Table D2.

CCSLC/CSEC Male vs. CCSLC/CSEC Male Cross-Validation Kolmogorov-Smirnov Test

Summary statistics:

Variable	Observations	Obs. with missing	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax)/Male	1817	0	1817	0.000	100.000	36.263	15.693
CCSLC/CSEC Final Mark (MinMax) Male Validation	732	0	732	0.000	94.505	36.017	16.143

Two-sample Kolmogorov-Smirnov test / Two-tailed test:

D	0.029
p-value (Two-tailed)	0.759
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation:

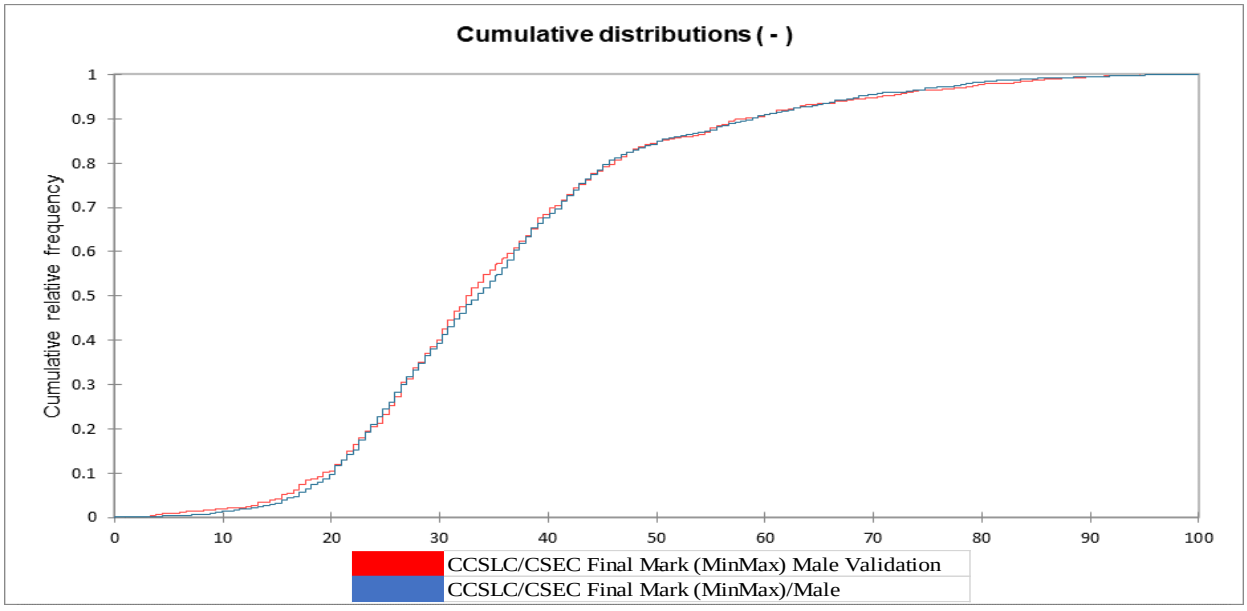
H0: The two samples follow the same distribution.

Ha: The distributions of the two samples are different.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Figure D2.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CCSLC/CSEC Male vs. CCSLC/CSEC Male Validation Distributions[10]



[10]Ties have been detected in the data.

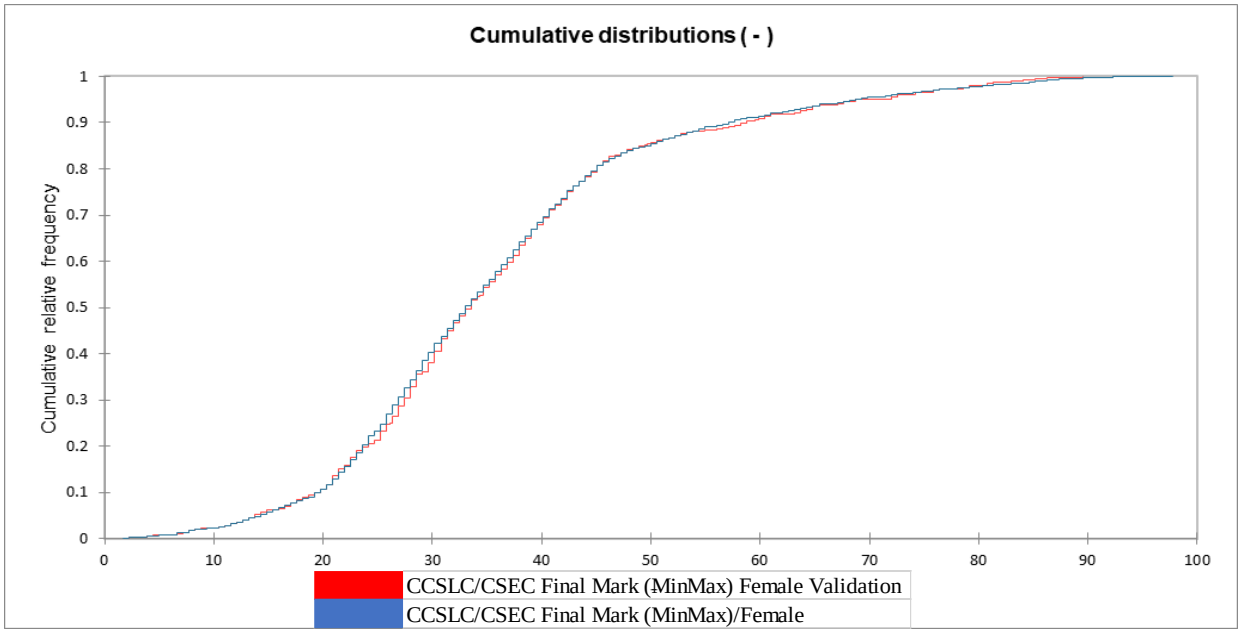
Table D3.

CCSLC/CSEC Female vs. CCSLC/CSEC Female Cross-Validation Kolmogorov-Smirnov Test

Summary statistics:							
Variable	Observations	Obs. with	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax)/Female	2476	0	2476	1.648	97.802	35.779	15.823
CCSLC/CSEC Final Mark (MinMax)/Female Validation	834	0	834	2.198	89.560	35.983	15.798
Two-sample Kolmogorov-Smirnov test / Two-tailed test:							
D	0.025						
p-value (Two-tailed)	0.838						
alpha	0.050						
An approximation has been used to compute the p-value.							
Test interpretation:							
H0: The two samples follow the same distribution.							
Ha: The distributions of the two samples are different.							
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.							

Figure D3.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CCSLC/CSEC Female vs. CCSLC/CSEC Female Validation Distributions[11]



[11]Ties have been detected in the data.

Table D4.

CSEC Only vs. CSEC Only Cross-Validation Kolmogorov-Smirnov Test

Summary statistics:

Variable	Observations	Obs. with missing	Obs. without	Minimum	Maximum	Mean	Std. deviation
CSEC Only Final Mark (MinMax) Male	1418	0	1418	1.630	97.826	34.540	14.578
CSEC Only Final Mark (MinMax) Male Validation	614	0	614	3.804	88.043	34.241	13.475

Two-sample Kolmogorov-Smirnov test / Two-tailed test:

D	0.036
p-value (Two-tailed)	0.619
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation:

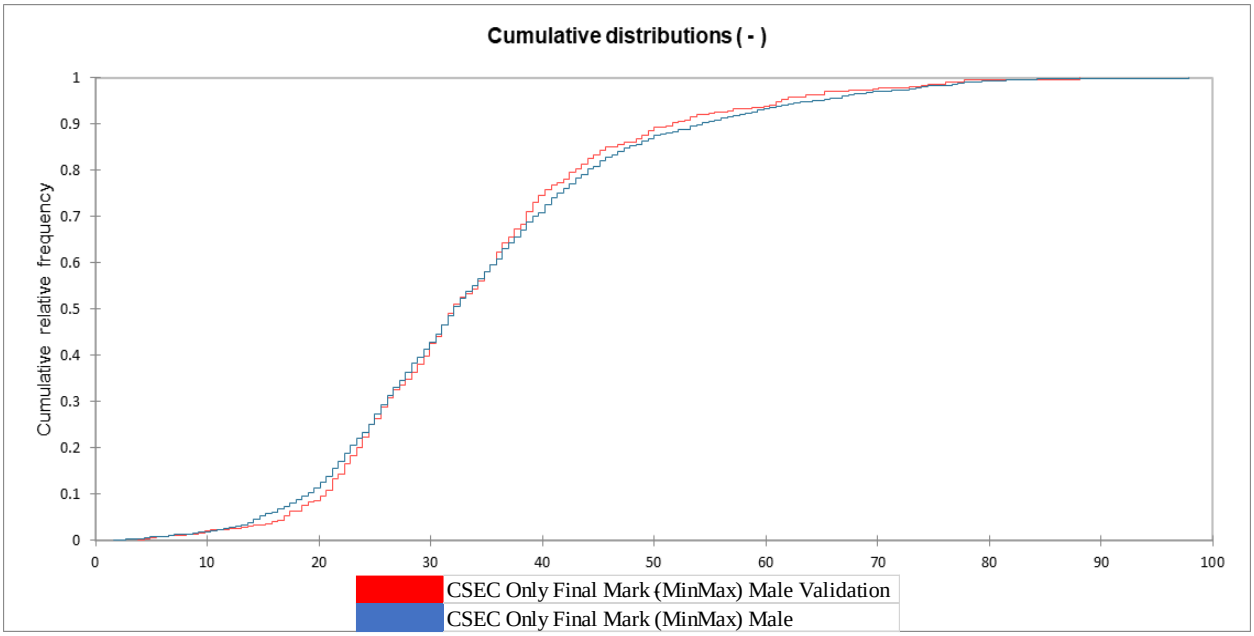
H0: The two samples follow the same distribution.

Ha: The distributions of the two samples are different.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Figure D4.

Two-sample Kolmogorov-Smirnov test / Two-tailed test: CSEC Only vs. CSEC Only Validation Distributions[12]



[12]Ties have been detected in the data.

Table D5.

CCSLC/CSEC Male vs. CSEC Only Male Cross-Validation Independent Two-Sample t-Test

Summary statistics:

Variable	Observations	Obs. with	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax) Male Validation	732	0	732	0.000	94.505	36.017	16.143
CSEC Only Final Mark (MinMax) Validation	614	0	614	3.804	88.043	34.241	13.475

t-test for two independent samples / Upper-tailed test:

95% confidence interval on the difference between the means:
[0.447, +Inf [

Difference	1.776
t (Observed value)	2.200
t (Critical value)	1.646
DF	1343.970
p-value (one-tailed)	0.014
alpha	0.050

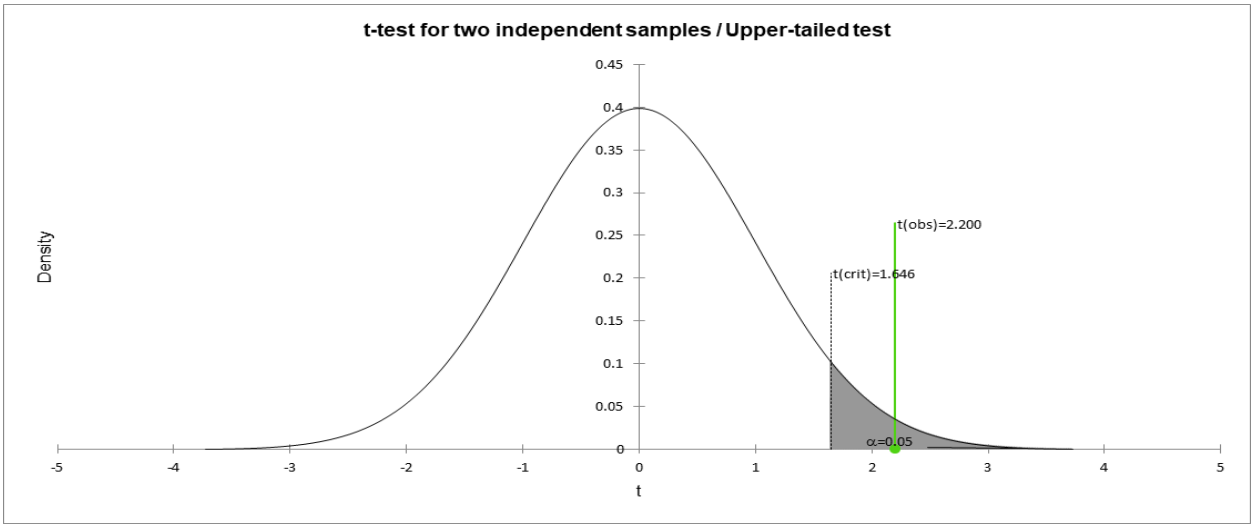
The number of degrees of freedom is approximated by the Welch-Satterthwaite formula
The critical t is estimated using the Cochran-Cox approximation

Test interpretation:
H0: The difference between the means is equal to 0.
Ha: The difference between the means is greater than 0.
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

Figure D5.

CCSLC/CSEC Male vs. CSEC Only Male Cross-Validation Independent two-sample t-Test

Significant Increase in Male Average (Mean) Score[13]



[13] **$H_{1\text{-}0}$:** If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will not be a statistically significant increase in the average score.

$H_{1\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before taking the CSEC mathematics examination, there will be a statistically significant increase in the average score.

Table D6.

CCSLC/CSEC Male vs. CCSLC/CSEC Female Cross-Validation Independent Two-Sample t-Test

Summary statistics:

Variable	Observations	Obs. with	Obs. without	Minimum	Maximum	Mean	Std. deviation
CCSLC/CSEC Final Mark (MinMax) Male Validation	732	0	732	0.000	94.505	36.017	16.143
CCSLC/CSEC Final Mark (MinMax)/Female Validation	834	0	834	2.198	89.560	35.983	15.798

t-test for two independent samples / Two-tailed test:

95% confidence interval on the difference between the means:

[-1.555, 1.623]

Difference	0.034
t (Observed value)	0.042
|t| (Critical value)	1.963
DF	1528.610
p-value (Two-tailed)	0.967
alpha	0.050

The number of degrees of freedom is approximated by the Welch-Satterthwaite formula

The critical t is estimated using the Cochran-Cox approximation

Test interpretation:

H0: The difference between the means is equal to 0.

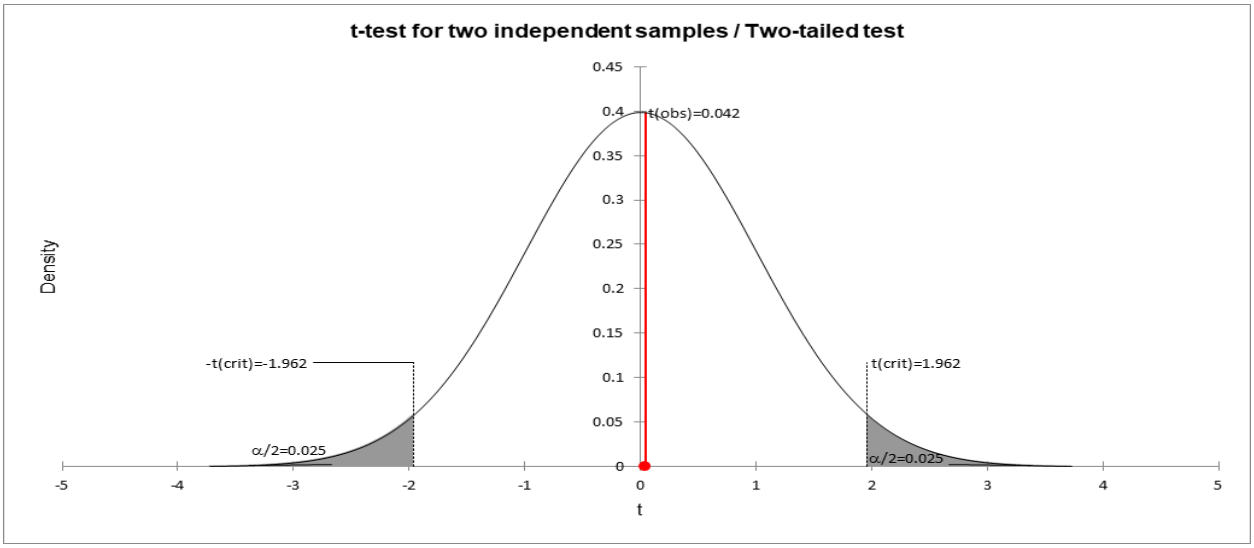
Ha: The difference between the means is different from 0.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Figure D6.

CCSLC/CSEC Male vs. CCSLC/CSEC Female Cross-Validation Independent two-sample t-Test

Statistically Insignificant Gender Differences in Scores[14]



[14] **$H_{2\text{-}0}$:** If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically insignificant difference between the average female and male scores.

$H_{2\text{-}1}$: If a male candidate takes the CCSLC mathematics examination before the CSEC mathematics examination, there will be a statistically significant difference between the average female and male scores.

Appendix E: Proposal Approval

Dear Mr. Griffith:

On behalf of the Gwynedd Mercy University Institutional Review Board, I am pleased to inform you that the Board has reviewed your research proposal and has determined that the proposal, as submitted, is **APPROVED EXEMPT.**

This approval is for a period of one year from the date of this letter and will require a formal submission for re-approval with the IRB along with a progress report should it extend beyond the one-year timeline.

The IRB shall have the authority to suspend or terminate approval of research that is not being conducted in accordance with the IRB's requirements or that has been associated with unexpected serious harm to subjects. Any suspension or termination of approval will be determined by the committee as a whole, shall include a statement of the reasons for the IRB's action, and shall be reported promptly to the principal investigator and appropriate institutional officials. Should any changes need to be made to the protocol during the period of approval, you must submit a revised protocol using form IRB-007 to the IRB for approval before implementing the changes. Should any problems or adverse events occur during the research, these must be reported to the IRB in a written report in accordance with IRB guidelines.

For all "EXPEDITED" or "FULL" reviews, the principal investigator must inform the IRB in writing when the research project has been completed through the submission of a study completion form (IRB Form 011) with a summary of the research and records and copies of manuscripts or abstracts resulting from the approved research.

We appreciate your adherence to the standards designed to protect the rights of human subjects utilized in research studies and wish you luck in your proposed research. If you have any questions regarding the IRB's decision or any part of the IRB process through the completion of your study, please contact the IRB Administrator.

Sincerely,

Dawn L. Hayward, Ph.D.
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IRB Administrator
Gwynedd Mercy University
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Gail E. Christiansen.
IRB Coordinator
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christiansen.g@gmercyu.edu

Appendix F: CITI Certificates

Figure F1.

CITI Social and Behavioral Responsible Conduct of Research

Figure F2.

CITI Social and Behavioral Research – Basic/Refresher

Figure F3.

CITI Information Privacy Security (IPS)

Figure F4.

CITI Conflicts of Interest