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Investigating the Relationship among High School Students' Mathematics Anxiety, Attitude towards Mathematics and Mathematics Achievement

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Abstract

This research design is quantitative, cross-sectional survey design that investigated the relationships among 700 fourth-form students' (aged 14 - 16 years) mathematics anxiety, attitude towards mathematics and their mathematics achievement. This study was conducted at a co-educational secondary school located in Providenciales, Turks and Caicos Islands. The data related to students' mathematics anxiety, attitude towards mathematics and mathematics achievement were collected with the use of modified shortened math anxiety scale (mAMAS), the Short Form attitude towards mathematics scale (ATMI-Short Form) and a teacher-made End-of-Term mathematics examination, respectively. This data was analyzed using Pearson correlation and Spearman rank order correlation. The results showed that there was a negative correlation and a non-significant between 4th-form students' mathematics anxiety and their academic achievement, a medium significant positive correlation between 4th-form students' attitude towards mathematics and their mathematics academic achievement, and a great significant negative correlation between 4th-form students' attitude toward mathematics and their mathematics anxiety. However, the correlation was greater between students' mathematics anxiety and their attitude towards mathematics.

Keywords: Attitude; anxiety; data ; achievement.

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1. Introduction

Mathematics can be defined as an unique subject, which provides students with the prerequisite skills, knowledge, and attitudes needed to accomplish and function effectively, not only in the mathematics classroom but also in other scientific disciplines, for example physics, chemistry; as well as in everyday life and the worldwide environment [1]. Because of distinctive characteristics of mathematics, as the world becomes technologically driven, mathematics and its application are quickly becoming indispensable to function effectively in 21st-century society, resulting in a demand for mathematically proficient students [2]. According to [3], having strong mathematics knowledge and skills is becoming critical for students' academic success and future careers. Mathematics helps students to improve their reasoning and problem-solving skills by their critical and analytical thinking skills [4]. Reference [5] state that achievement in mathematics is a foundation to prestigious jobs and future career choices. Hence, improving students' academic achievement in mathematics is very important for student success. This is especially important for the science, technology, engineering, and mathematics (STEM) workforce [6] Because the foundation for the development of reasoning, logical thinking, and other learning skills is a strong mathematics knowledge. Considering the important role mathematics plays in society and an individual's daily life, stakeholders in education have placed predominant emphasis on mathematics teaching and learning. Globally, regardless of the efforts to produce students who are mathematically literate, the predominance of low achievement and low participation still plagues the classrooms [3].

1.1 Students' Mathematics Achievement in Secondary School in Turks and Caicos Islands

Consistent with the global context, students from the Turks and Caicos Islands, which is the context for the research, also struggle with mathematics at all levels in educational institution. Details relating to the research context are provided later in the research method section. This research aims at the secondary school level, therefore achievement data related to student achievement is present in Table 1. Table 1 show data on the percentage of students who passed the Caribbean Secondary Examination Certificate (CSEC) mathematics examinations for the Turks and Caicos Islands for the period 2015 – 2019. The CSEC examinations are high-stakes, external examinations administered to students within the Caribbean region at the secondary level. The data indicates that, over five years, the average pass rate of students studying mathematics was 44.2%. In the years 2016-2017 school year, more than 60.0% of the candidates who sat the CSEC Mathematics Examination were unsuccessful, resulting in a percentage pass rate of 37.8 and 38.2 percent, respectively. Comparing the data of candidates that passed the exam in 2016 and 2017 to that in 2015, a decrease in the percentage of candidates that passed in both years was observed. In the year 2018, there was an increase in the percentage of candidates that passed the examination when compared to 2017, the data of the results showed that 58.9% of the candidates were successful. However, this was not the same for the year 2019 as there was a 14.9% decrease from 2018 in the percentage of candidates that passed the examination, thus resulting in 44. 0% being successful. In 2018, the greatest percentage of passes was reported, with approximately 60.0% of the candidates successfully completed the CSEC mathematics examination successfully. This result represents a great improvement over the period of 3 years, that is 2015, 2016 and 2017. The statistics indicated that over the five years observed, less than 50.0% of candidates completed the examination each year successfully except for 2018, where the percentage 58.9% of

students were successful.

CSEC Mathematics Data for Turks and Caicos Islands

from 2015 – 2019

Table 1

Year	Percentage of students who passed (%)
2015	42.0
2016	37.8
2017	38.2
2018	58.9
2019	44.0

Also, the researcher examined the CSEC mathematics examination data for the research site for the same period from 2015-2019. In Table 2 the percentage of students who passed the CSEC mathematics examinations for the research site for the period 2015 – 2019.

CSEC Mathematics Data for the research site

from 2015 – 2019

Table 2

Year	Percentage of students who passed (%)
2015	37.0
2016	34.8
2017	38.3
2018	54.4
2019	45.5

The data in table2 indicates that the average pass rate was 42.0% over the five years. In 2015, 2016 and 2017, more than 60.0% of the candidates who sat the CSEC mathematics examination were unsuccessful, thus resulting in 37.0%, 34.8 % and 38.3%, respectively receiving a pass grade. When the percentage of candidates that passed the exam in 2015 was compared with 2016, there was a reduction of 2.2% of candidates that were successful in the CSEC mathematics examination. In 2017, 38.3% of the candidates were successful in the examination, this was a small increase of 3.5% of candidates passing when compared to the year 2016. In 2018, there was an increase in the percentage of candidates that passed the examination compared to 2015, 2016 and 2017. In 2018, 54.4% of the candidates were successful in their examinations. This was a great improvement in the percentage of students that passed, as more than 50.0% of the candidates were successful in their examination. This percentage passed represented a 16.1% increase when compared to 2017. However, this was not observed in 2019 as there was a 8.9% decrease in the percentage of candidates that passed the examination when compared to 2018, thus resulting in 45.5% being successful.The students' mathematics achievement data presented in Tables 1 and 2, that high school mathematics need to improve their mathematics achievement.

1.2 Initiatives to improve the academic achievement of students of the Turks and Caicos Islands

In efforts to improve the mathematics academic achievement of students of the Turks and Caicos Islands, the Ministry of Education has taken initiatives to improve teaching and learning., The Ministry of Education (MOE), In the Turks and Caicos Islands conduct professional development sessions such as workshops and seminars for teachers as steps to improve teaching and learning across all subject areas. The aim of these workshops and seminars include using gender-neutral language in the classroom to lessen gender differences, allow students to work in small groups activities and promote use of technology in the classroom to enhance learning. This was a part of Turks and Caicos Islands education sector plan 2018-2022 to enhance students' success in the classroom. Also, each student received a Chromebook which would enable them to participate in activities requiring a technological device. It was expected that these initiatives would lead to improved teaching and learning, which would ultimately enhance students' academic achievement in the various disciplines. However, in terms of initiatives that focus specifically on improving students' mathematics academics achievement, limited actions were to have been taken. Mathematics teachers at the research site help the students by providing them with supplies they need to complete school assignments such as geometry sets, calculators and graph papers. These actions were taken by the teachers as was believed providing the students with material needed to complete school assignments, will enable them to actively participate in the lessons, which would result in improvement in their mathematics academic performances and achievements. Also, the teachers assist the students by having extra classes for the students to reinforce the concepts taught. Nevertheless, despite the measures taken by the MOE and the mathematics teachers at the research site, low achievement in mathematics is still a problem. Considering the measures taken to improve students' academic achievement in mathematics and the data shown locally and specifically at the research site, conclusions can be drawn that new insights are needed to more fully understand the factors that affect the student's mathematics achievement. A good understanding of these factors is needed to plan interventions in order to improve student mathematics achievement.

1.3 The Researcher's experiences and observations of the students at the research site

The researcher is a teacher of mathematics and science with nine years of professional teaching experience at the secondary level. Also, the researcher has been a teacher at the research site for approximately two years. The researcher has observed some of the students displaying negative reactions toward mathematics during instruction at the research site. On several occasions, while teaching, the researcher notices that some of the students seemed to be worried and frustrated as the researcher explained a particular concept or asked questions about the content. Also, the researcher has that some students were nervous and shaking their feet when they were given mathematical tasks to complete. Also, some students would repeatedly express, 'I cannot do mathematics', 'I hate mathematics with an expression, mathematics is my worst subject." Most of the time in the researcher's mathematics classes, these students do not even attempt to try, some will attempt but easily give up, some of the students will skip classes and others will merely sit and ignore the teaching entirely, regardless of the researcher's varied attempts to motivate students, make the teaching and learning process interactive and enjoyable, as well as to engage students through the use of multimedia videos, games, interactive PowerPoint presentations and other activities. Several research suggestions that these strategies and methodologies are likely to increase student motivation and engagement in mathematics class, as well as make the teaching and learning process interactive and enjoyable. The actions students display has made it difficult for the researcher to effectively carry out her role as a teacher.

Similarly, mathematics teachers of other classes and schools have expressed the same concern with some of the students. These seemingly negative attitudes toward mathematics and the fear that the students showed when confronted with mathematics activities make the teaching and learning process difficult for both teachers and students. This negative attitude towards mathematics affects effective learning, which in turn has a negative effect on students' learning outcomes and performance in mathematics [7]. Students' attitude towards mathematics affects whether they find mathematics to be enjoyable, valuable and essential to be successful in school and future career goals [8]. Similarly, mathematics anxiety (fear of mathematics) has been shown to obstruct cognitive functions as well as information processing [9]. Furthermore, when the students the researcher teaches have been assessed, the grades they receive reveal a significant need for assistance, as they struggle to meet the 60% pass mark stipulated by the research site. Nonetheless, there are some students who will participate in the class activities and enjoy the teaching and learning of mathematics. These students sometimes attain grades that are favorable to the standard of the school. Empirical research suggests that there are different factors that influence students' mathematics achievement. Therefore, this empirical research aims to explore some possible factors and their influence on the mathematics achievement of students in the Turks and Caicos Islands.

In efforts to assist the mathematics students at the research site, the researcher believes that exploring students' mathematics anxiety and attitude towards mathematics will be a good starting point to understand some of the issues students at the research site are experiencing. Further discussions regarding the reasons for exploring these two affective constructs are presented under the sub-heading 'Research significance'.

1.4 Cognitive and affective domains relate to students' mathematics achievement

Research in mathematics has shown that students' cognitive domain plays an integral role in their mathematics

achievement [10]. The cognitive domain concerns the recall or recognition of knowledge and the development of intellectual abilities and skills [11]. Cognitive factors such as preferred learning styles (Bosman, & Schulze, 2018 and critical thinking skills [4] are factors that have been examined in relation to students' achievement in mathematics and have been shown to influence students' mathematics achievement. Reference [12] mentioned that mathematics has been cited as a difficult subject for students to grasp some formulae are too complex and some problems are difficult to solve. Though mathematics is a challenging subject, it is one of the problems that caused these cognitive issues. When students are confronted with mathematics, many of the students and adults feel nervous, tense, uncomfortable, or anxious [13]. Reference [14] posits that while cognitive measurements have an impact on student outcomes, other non-cognitive issues also affect students' qualities of work and student academic achievement. Hence, issues relating to both the cognitive and affective domains should be taken seriously, as it is reported that students are still facing challenges with both components [3,6]. According to research students' achievement in mathematics can be affected by several affective factors. Some of these factors are mathematics self-efficacy [15]; attitude toward mathematics [16]; and mathematics anxiety [3,17]. These are just a few as there are other variables such as interest in mathematics [18] and students' motivation in mathematics [19] along with others. These studies indicate that there is a relationship between students' affective domain and teaching, learning and performance related to mathematics.

Considering the challenges students are facing, Mathematics Anxiety (MA) is one of the many variables relating to students' affective domain that has recently been frequently explored [3,17]. Mathematics Anxiety can be (MA) defined as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" [20]. Studies have indicated that mathematics anxiety may have a direct or indirect impact on students' mathematics attitudes toward arithmetic issues (Kargar and his colleagues 2010). According to [21], students' attitude towards mathematics is referred to "as a person's tendency to like or to hate mathematics, to deal with or to avoid mathematical activities, his or her belief of being successful or not in mathematics or a belief that mathematics was useful or not" (p. 632). Students' attitudes affect their mathematical academic achievement, which include liking, enjoying, and showing interest in mathematics or the opposite reactions [22]. This suggests that students' attitude towards mathematics affects their learning. Students' negative attitude toward mathematics affects their learning, which in turn affects their learning outcomes and academic achievement [7]. This means that a student's attitude may have a key role in whether they succeed in the discipline**.**

1.5 Significance for Research

This study is significant because of three main reasons. Firstly, as mentioned above (see Research Rationale), as it relates to empirical research focusing on the relationships among high school students' mathematics anxiety, mathematics attitudes, and their mathematics academics achievement, there seems to be a shortage of literature both internationally and within the Caribbean context.

Secondly, given that the grade 10 (4^{th} form) high school students (aged 15 -16 years) had recently transitioned to the research site and would be sitting their CSEC examination the next school year. The researcher believes that they would be an excellent starting point for exploring the research topic, considering that this would be the first

empirical research conducted in the island relating to the topic. Additionally, by 4th form students would have had well-established/developed mathematics anxiety and mathematics attitudes and a pattern of mathematics performance. This makes it an appropriate juncture to investigate these research interests.

Finally, the researcher feels confident that the results obtained from this research will benefit the present researcher as well as mathematics teachers at not only the research site but also other educators in the field of mathematics both locally and internationally. This is likely to be beneficial because by understanding students' attitudes and emotions regarding mathematics, difficulties to learning can be eliminated and students will be able to progress in the discipline [3]. It is also hoped that with the results obtained from this research, the researcher will gain new insights that are essential to enhancing her own mathematics teaching practice and be able to share these insights with the teachers at the research site as well as other stakeholders in education. The insights gained could be used to develop strategies to support secondary mathematics students in ways that have not been previously explored. With new insights, educators can reduce in one way to alleviate students 'mathematics anxiety and foster a positive attitude towards mathematics or further explore other affective constructs that may be affecting students' mathematics achievement.

1.6 Purpose of Research

Considering the above-mentioned research gaps identified with the present research seeks to investigate the relationships between and among 4th form high school students' (aged 15-16 years) mathematics anxiety, attitude towards mathematics and their mathematics achievement. The research also seeks to determine the extent to which students' mathematics anxiety and attitude towards mathematics jointly predict their mathematics achievement.

1.7 Research Questions

This research will be guided by the following research questions. This research will be a non-experimental study, hypotheses are not appropriate [23].

1. What is the relationship between 4th form secondary students' mathematics anxiety and their mathematics achievement?
2. What is the relationship between 4th form secondary students' attitude towards mathematics and their mathematics achievement?
3. What is the relationship between 4th form secondary students' mathematics anxiety and their attitude towards mathematics?
4. What are the relationships among 4th form secondary students' mathematics anxiety, attitude towards mathematics and their mathematics achievement?
5. To what extent do 4th form students' mathematics anxiety and attitude toward mathematics jointly predict their mathematics achievement?

1.8 Research Definitions

Mathematics Anxiety (MA) can be defined as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" [20]. In this study, mathematics anxiety refers to students' anxiousness when exposed to mathematics or anything that involves mathematics.

The definition of Attitudes Toward Mathematics (ATM) is a person's tendency to like or to hate mathematics, to deal with or to avoid mathematical activities, his or her belief of being successful or not in mathematics or a belief that mathematics was useful or not" [23]. In this research students' attitudes to mathematics refer to their enjoyment of mathematics, mathematics motivation, self-confidence in mathematics and perceived value of mathematics. Mathematics Achievement refers to a single assessment of a student's knowledge at a certain period. This single measure will be obtained from the students' end-of-first-term examination that will be done in December 2022.

1.9 Theoretical Framework

In this research, students' attitude towards mathematics is based on the ABC Model of attitude. The ABC model of attitude consists of three distinctive components: affective (A), behavioral (B), and cognitive (C) [22]. This model was chosen because it provides an essential theoretical framework for mathematics attitudes that conceptualizes an attitude as a mixture of three separate components: affective, behavioral, and cognitive. In this research, students' attitude refers to their enjoyment of mathematics, mathematics motivation, self-confidence in mathematics and perceived value of mathematics. All three components of the ABC model affect each other or have some impact on each other. The way in which someone feels will impact the way they behave or think. It is very important to know how students feel about mathematics, which will impact how they present their solutions or the processes for the questions or problems given. This will in turn demonstrate how the students think about mathematics, indicating the reasons for their academic scores obtained from their assessments.

Mathematics anxiety is a unique construct, given that it has been identified with two components: cognitive and affective. The cognitive component relates to worry that is associated with failure, while the affective component relates to emotions such as nervousness, pressure, and related physiological responses felt in evaluative settings. Students' fear of mathematics will impact their cognitive and affective domains, thus impacting the behavioural domain, whether positively or negatively. In this study, students' mathematics anxiety is based on two competing theories: Cognitive Interference Theory and the Deficit Theory. The Cognitive Interference Theory' posits that mathematics anxiety influences mathematics performance [24], while the Deficit Theory posits that past experiences with low mathematics performance and memories of those experiences cause future mathematics anxiety to be higher [25, 9]. Some researchers are in agreement with the 'Cognitive Interference Theory' while others support the 'Deficit Theory"; regardless of the theoretical stance, many have a consensus that there is a relationship between students' mathematics anxiety and their mathematics achievement.

Figure 1 exhibits the bi-directional causality of mathematics anxiety and mathematics achievement, attitude towards mathematics and mathematics achievement, mathematics anxiety and attitude towards mathematics

achievement.

Mathematics Anxiety, Attitude towards mathematics and Mathematics Achievement

Conceptual Map

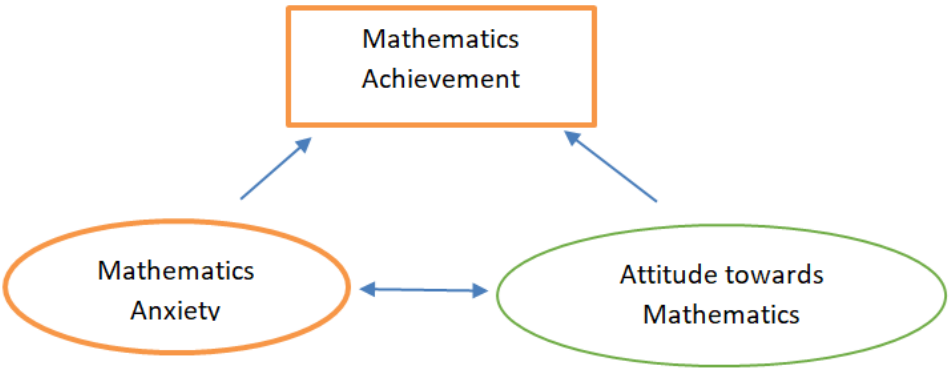

Figure 1

Both the Cognitive Interference Theory and the Deficit Theory present the causality between mathematics anxiety and mathematics achievement in a linear or unidimensional model. However, there are researchers who view the causality to be bi-directional and they purport that both mathematics anxiety and mathematics performance affect each other in a cyclical manner [13]. While the focus of this research is not on exploring the causal relationship between/among students' mathematics anxiety, attitude towards mathematics and mathematics achievement, it aims to add to the body of knowledge relating to the correlation among mathematics anxiety, attitude towards mathematics and mathematics achievement.

2. Literature Review

This chapter provides an extensive literature review of research conducted on the relationship between students' mathematics anxiety and their mathematics achievement, their attitude towards mathematics and mathematics achievement, and students' mathematics anxiety and attitude towards mathematics. The chapter also provides literature on the extent to which students' mathematics anxiety and attitude towards mathematics predict their mathematics achievement.

2.1 Overview of Mathematics Anxiety

Several studies have been undertaken to try and understand nature, prevalence and resolution of mathematics anxiety [25, 3]. Mathematics anxiety has been viewed as a dynamic construct [26] and as a result, it has been defined differently by different groups of scholars (Cipora and his colleagues 2022; Orbach and his colleagues 2019). In early research [20], defined mathematics anxiety as "a feeling of tension and anxiety that interferes

with the manipulation of numbers and the solving of mathematical problems in ... ordinary life and academic situations" (p.551). Reference [27] defined mathematics anxiety as "the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem" (p. 63). Reference [1] defined mathematics anxiety as "a feeling of tension, apprehension, or fear that interferes with mathematics performance" (p. 1). In recent research, [25] defined mathematics anxiety as "a negative emotional reaction to mathematics, which can interfere with the ability to perform mathematical tasks.

The four descriptions of mathematics anxiety have characteristics in common that are linked to feelings. Examples of these include feelings of tension, helplessness and fear. Although some of these characteristics are different, the overall repercussions of mathematics anxiety are the same. All four researchers have concluded that mathematics anxiety can make it difficult to complete mathematical tasks. Reference [20] discussed mathematics anxiety from an affective perspective, highlighting that negative emotions can interfere with mathematical tasks and performances. Reference [20] further explained that mathematics anxiety can cause negative consequences in real life situations. Reference [28] definition, they gave a clear description of the feelings associated with mathematics anxiety and explained how working memory is affected (mental disorganization). Reference [25] definition however gave a wider viewpoint by stating that mathematics anxiety is "a negative emotional reaction to mathematics", Carey did not specify the reactions, as each individual negative reaction may manifest itself differently. Thus, supporting [26] stance that mathematics anxiety is a dynamic construct. This diversity can be seen in the numerous meanings and in the various manifestations that each person makes of it.

Regardless of how mathematics anxiety is perceived, there is consensus among the research community that more research related to this research domain is needed to fully understand it [25,28]. Mathematics anxiety has been explored at different educational levels and among different age groups. Some of these studies have been conducted at the primary level [29,30], the secondary level [31], and the tertiary level [32, 33] involve children, adolescents and adults, respectively [25]. This research focuses on students at the secondary level. Reference [3] postulated that at the secondary school level, mathematics anxiety appears to increase. Reference [8] underscored that "students are exposed to more difficult concepts at the secondary level. As a result, the emotional, physical, and mental health of the students is affected as well" (p.3). Given that there are limited studies both internationally and locally relating to the relationship between secondary students' mathematics anxiety and their mathematics achievement; as well as the extent to which mathematics anxiety and attitude towards mathematics predict mathematics achievement, the researcher aims to fill this gap. This sub-section focuses on literature relating to the relationship between secondary students' mathematics anxiety and their mathematics achievement.

2.2 Relationship between Students' Mathematics Anxiety and their Mathematics Achievement

Irrespective of the educational level and age group, studies conducted on students' mathematics anxiety and their mathematics achievement have revealed that there is a relationship between the variables, however, the findings have been inconsistent. Numerous studies have reported a negative correlation between students' mathematics anxiety and their achievement [6, 31]. This means that the students with lower mathematics

achievement levels showed higher mathematics anxiety than students with higher mathematics achievement levels. However, this is not always the case. Recent study (e.g. Luu-Thi and his colleagues 2021) have found a positive correlation between students' mathematics anxiety and their achievement where students with higher mathematics achievement levels showed higher mathematics anxiety levels than students with lower mathematics achievement levels.

Specifically,[34] investigated the relationship between mathematics anxiety and gender, grade, career choices, and academic achievement in Grade 10, 11, and 12 students from Vietnam. The study consisted of a combined total of 1548 students from nine high schools; 513 10th graders (33.1%), 462 11th graders (29.8%), and 573 12th graders (37.0%); with 570 males and 978 females. However, the age of the respondents was not specified. The data analysis revealed that there was a significant, weak positive correlation between the level of mathematics anxiety and mathematics achievement ($r = 0.064$, $p < 0.05$) among students. The result showed that individuals who have high levels of mathematics anxiety tend to have higher average scores in mathematics. The findings presented in this study were contrary to the findings presented in most previous studies from different jurisdictions, including Malaysia, India and other countries outside of the Caribbean [6, 24]. Reference [34] found that students in Grade 12 are affected more by mathematics anxiety than students in grades 10 and 11. The authors posited that this might be due to demanding academic tasks and complex academic content. Further stating that for Grade 12 students to enroll in their desired university, they must pass a graduation examination. Hence, this academic pressure, which may also be a consequence of parental pressure impacts students' mental health and leads to psychological problems related to mathematics anxiety. This, therefore, shows that the value placed on academics plays an integral role in students' achievement. Given that the students are pressured to perform well in academics, in this case, mathematics, this academic pressure may lead to students experiencing symptoms of mathematics anxiety. Notably, although the possible reasons given by the authors for students' mathematics anxiety may be plausible, stating that grade 12 students are affected more by mathematics anxiety may be misleading, given that the sample size was not equally distributed. Since there were more students from the 12th grade participating, 3.9% more when compared to grade 10 and 7.2% more when compared to grade 11; this may result in the results showing that 12^{th}-grade students are affected more by mathematics anxiety.

Reference [8] conducted a quantitative study which investigated the relationships between Form four students' mathematics anxiety levels and their mathematics achievement. The respondents in the study comprised a total of 56 students from a high school in the Sepang district of Selangor. The findings revealed that there was a weak and non-significant negative correlation between the students' mathematics anxiety and mathematics achievement. The findings also revealed that the students who perceived themselves to be low achievers had the highest levels of anxiety. Similarly, [31] conducted a study which aimed to identify the level of mathematics anxiety and its relationship with the achievement of Form Four students in Perak Tengah district, Malaysia. The study consisted of 190 students; however, their ages were not disclosed. The findings revealed that there was a low, significant negative correlation between mathematics anxiety and mathematics achievement, in which students with high math anxiety showed poor mathematics performance and vice-versa. Reference [3] findings also support the findings of [31]. Similarly, data from the 2012 Program for International Student Assessment (PISA), which tested 15-year-olds' mathematics academic achievement worldwide, showed that in 63 of the 64

education systems that participated in this assessment, mathematics anxiety is negatively related to mathematics achievement [35]. These correlations support the findings of [31] meta-analyses study which found significant negative correlations between mathematics anxiety and achievement for secondary grades, r = −.36.

The studies reviewed thus far were conducted in jurisdictions outside of the Caribbean. Within the Caribbean, Mitchell and George (2022) explored the correlation between mathematics achievement and mathematics anxiety among 62 fourth and sixth grade primary level students (aged nine to 12 years). The findings revealed a small, nonsignificant positive and negative correlations between mathematics performance and mathematics anxiety for grade four and six students, respectively. With only a few such studies in the Caribbean region, the current researcher concludes that there is a dearth of literature, especially at the secondary level relating students' mathematics anxiety and their mathematics achievement. The proposed research aims to add to the body of existing literature. The overall pattern of findings suggests that there is a connection between mathematics anxiety and achievement, but the direction of the relationship is unclear.

2.3 Overview of Attitude Towards Mathematics

Attitude towards mathematics, according to [21], is "a person's tendency to like or to hate mathematics, to deal with or to avoid mathematical activities, his or her belief of being successful or not in mathematics or a belief that mathematics was useful or not" (p. 632). Different studies have evaluated students' attitudes toward mathematics using different components of attitude (Hwang & Son, 2021). For example, [36] used motivation, enjoyment, self-confidence, and perceived value as components of attitude toward mathematics;[21] used self-confidence in mathematics, perceived usefulness, enjoyment of mathematics, mathematics anxiety, and intrinsic motivation; while [37] used emotions disposition, vision of mathematics and perceived competence. Regardless of the components used, many researchers have commonly measured attitudes toward mathematics using a Tripartite Model (ABC Attitude Model): "affect (A), behaviour (B) and cognition (C). Affect is the emotional component consisting of feelings and emotions such as enjoyment and anxiety that are associated with an attitude object (in this case mathematics). The behaviour is the action component consisting of predispositions to act in a particular way towards the attitude object. Cognition is a mental component that consists of beliefs and perceptions people hold about the attitude object"[21].

Like mathematics anxiety, research has been conducted to explore the relationship between students' attitude towards mathematics and their mathematics achievement. Students' attitude towards mathematics can be positive, these might either appear as liking, enjoying, and showing interest in mathematics or negative which includes the opposite reactions [21]. Attitude is regarded by many researchers as a key contributor to higher or lower mathematics achievement [24, 29] posited that positive and negative attitudes toward mathematics are due to accumulated experiences that influence students' psychological state, as a result, their behavior reflects their attitude. Hence, this research focuses on students at the secondary level. This sub-section focuses on the relationship between secondary students, attitude towards mathematics and their mathematics achievement; as well as the extent to which students' mathematics anxiety and attitude towards mathematics predict mathematics achievement.

2.4 Relationship between students' attitude towards mathematics and their mathematics achievement

The relationship between students' attitudes toward mathematics and mathematics achievement has gained a lot of focus from researchers [38]. This is because students' attitudes toward mathematics could help or hinder their learning [7]. Several studies have found a positive correlation between students' attitude towards mathematics and their mathematics achievement [38, 21]. However, contrary to these findings, Idris and his colleagues (2021 found that students' attitude towards mathematics and their mathematics achievement are negatively correlated. Specifically, [39] investigated the correlation between secondary students' attitudes toward mathematics and mathematics learning achievement. The study revealed a weak, negative, but significant, correlation between students' attitudes toward mathematics and mathematics learning achievement. This implies that though a student may have a highly positive attitude towards mathematics, it does not guarantee that his/her mathematics achievement score will be high. A student may have a medium or low attitude towards mathematics and have high achievement; while a student may have low achievement and have a high positive attitude. However, given that [38] study is the only one thus far that has reported a negative correlation between students' attitude towards mathematics and mathematics achievement, this call for closer examination of the scale that was utilized in the study and how it was interpreted. Notably, the scale used in [38] study has also been utilized in [40] study that has reported a positive relation between students' attitude towards mathematics and mathematics achievement; this therefore shows that further investigation is needed. Additionally, the studies did not disclose whether students' mathematics scores were obtained from a single score at a particular point in time or an accumulative score, which might have had an impact on the results obtained.

Many researchers have reported a positive association between students' attitudes toward mathematics and their mathematical achievement [38,21]. Specifically, [24] conducted a quantitative study in Banayoyo Lidlidda District in the Philippine to examine the relationship between the attitude of high school students towards mathematics and their level of achievement in mathematics. A total of 273 students from two public secondary schools participated in the study. However, the ages of the respondents were not disclosed. The results revealed that there was a positive and significant relationship between the students who scored high in mathematics based on their summary of grades and their attitude towards mathematics, indicating that students with a higher positive level of attitude towards mathematics tend to have better achievement in mathematics. Naungayan further asserted that if attitude toward mathematics were improved, math achievement would undoubtedly improve. Similarly, [38] quantitative study on the relationship between Singaporean students' mathematics attitude and their mathematics achievements showed a significant positive relationship. These results showed that students who like to study mathematics and pursue mathematics-related activities, believe that learning mathematics will result in a positive outcome and trust in their mathematical abilities, are the students that were more likely to have high mathematics achievement. This indicates that if the students have a positive attitude towards mathematics, it will promote or increase their mathematics achievement. [21] also revealed a positive relationship between students' attitude towards mathematics and mathematics achievement.

The results of the correlation analysis conducted in [39] study revealed contrast with several studies related to the correlation of attitudes and student achievement in mathematics which are generally positive [38]. The results reveal that further studies are needed related to the correlation between students' attitudes toward

mathematics and mathematics achievement. Given that the researcher aims to investigate the relationships among secondary students' mathematics anxiety, attitude towards mathematics and mathematics achievement, the results of this research will contribute to the limited body of existing literature.

2.5 Relationship between students' mathematics anxiety and their attitude towards mathematics

The relationship between students' mathematics anxiety and their attitude towards mathematics has also been explored in empirical research. However, [28] posit that the relation between the two constructs has not been explored extensively, which underscores the significance of the present study. Reference [28] explored the relationship between secondary school students' mathematics anxiety and their attitude towards mathematics. The study comprised 112 students with ages ranging from 14 to 17 years old, from a secondary private school in Kerala, South India. The findings revealed a positive correlation between students' mathematics anxiety and their attitude towards mathematics. "A positive correlation indicates that as one variable increases, so does the other" [40]. In this study by [28], higher scores on the mathematics anxiety scale relate to ease with mathematics. This, therefore, means that as students' mathematics anxiety scores increase the more relaxed students are when doing mathematics), their attitude towards mathematics also increases. This is like the findings of [32]. However, the scale used in the study by [28] is unlike other studies [32] which measured high anxiety scores as high levels of mathematics anxiety. Hence, a positive correlation was obtained between students' mathematics anxiety and their attitude towards mathematics.

In the study conducted by [32], a positive correlation would suggest that as students' mathematics anxiety scores increase (anxiousness towards mathematics), their attitude towards mathematics also increases. This is however not the case for [28]. This shows that different scales impact the way in which results are interpreted. As a result, researchers should pay close attention to scales used in various research and how they are interpreted, to prevent deducing wrong conclusions when comparing studies. At the university level, [33] investigated the connection between mathematics anxiety, attitudes toward mathematics and mathematical thinking. The study consisted of 203 students from a public university in Malaysia. Concerning the correlation between students' mathematics anxiety and their attitude towards mathematics, the findings revealed a significant, moderate and negative relationship between the two constructs ($r = .509$, $p < 0.05$). A negative correlation suggests that when students' mathematics anxiety increases, their attitude towards mathematics decreases. The researchers posited that mathematics anxiety might influence mathematics attitude towards mathematics problems directly or indirectly, where students develop avoidance behavior towards mathematics.

Similarly, [32] also reported that there is a negative correlation between mathematics anxiety and students' attitudes toward mathematics. Although the findings revealed that there was a negative correlation between mathematics anxiety and attitude towards mathematics, given that the students used in this study, similar to the study conducted by [32], were university students, the results obtained may not hold true for students at the secondary level. This is because studies have shown that there is a relationship between students' attitude towards mathematics and mathematics anxiety as it relates to their age [3]. Negative attitudes toward mathematics and mathematics seemingly increase when students reach secondary school age, persisting in post-secondary education and throughout adulthood [3]. The findings revealed in [32] and [33] research was contrary

(at first sight) to the finding of [28] study, which reported a positive correlation between student's mathematics anxiety and attitude towards mathematics. However, this is due to the scale that was used to measure students' mathematics anxiety in [28] study.

Recently, [41] done a meta-analysis that included 19 independent correlational studies to get a more comprehensive finding relating the relationship between students' mathematics anxiety and attitude towards mathematics. The study involved a collective sample size of 8,874 participants from 21 localities in Turkey., 21 effect sizes were calculated Out of the 19 independent studies included in this meta-analysis. The analysis collectively revealed a significant, negative, and large effect size (r = -.566) for the relationship between mathematics anxiety and attitude toward mathematics. According to [40], the effect size identifies the strength of the differences between groups or the relationships among variables. A large effect size means that research findings have practical significance. This means that the effect is significant to be meaningful in the real world. This is meaningful as the findings from the study will give a more comprehensive understanding of the relationship between students' mathematics anxiety and attitude towards mathematics, which may be used to determine if the results are useful.

This study showed the significant and robust link between mathematics anxiety and attitude toward mathematics. The study also indicated that when attitudes toward mathematics increase, mathematics anxiety decreases. Similarly, as mathematics anxiety increases, so do the negative attitudes toward mathematics. The effect size for the relationship between mathematics anxiety and attitude toward mathematics obtained in this meta-analysis aligns with other research studies [32, 33]. Given that the study employed a meta-analysis, disagreements in different literature can be resolved, a broader perspective on the topic can be obtained in order to obtain a comprehensive understanding and future studies will be better guided. Furthermore, the findings of meta-analysis studies can help education stakeholders make effective choices. However, all the studies used in [41] study were conducted outside the Caribbean context. Therefore, the findings are still inconclusive regarding the Caribbean context.

The literature review undertaken here reveals that there is a need for advanced research relating to the individual constructs (students' mathematics anxiety, attitude towards mathematics and mathematics achievement) and their inter-relationships. Although there has been extensive research involving these variables, the portrait of the relationships among the variables is far from conclusive because many studies have only looked at the constructs individually, not collectively [28]. Additional research is needed both at the secondary level as well as in the Caribbean context. This would assist researchers and educators in gaining a better understanding of the relationship between these two constructs, as a result, they will be able to put procedures into practice to better support all students and improve their mathematics academic achievement. Therefore, the current study aims to address the identified research gaps by investigating the relationships among secondary students' (age 15 -16 years old) from the island of Turk and Caicos, Providenciales, mathematics anxiety, attitude towards mathematics and mathematics achievement.

3. Methodology

This chapter provides a comprehensive description of the research methodology that was followed in doing this study. It gives details about the research design, research setting, population and sample, sample size, as well as the rationale underpinning these decisions. It also gives information involving the instruments that were used for data collection, and a description of the data collection procedures, the reliability and validity of the instruments and methods of data analysis. Lastly, this chapter discusses the ethical considerations that were followed.

3.1 Methodology and Research Design

This research adopted a quantitative approach to explore the relationships among 4th form students' (aged 15-16 years) mathematics anxiety, attitude towards mathematics and mathematics achievement. Quantitative research, according to [42], gathers numerical data and performs mathematical analysis utilizing statistics to describe, identify trends, explain and make predictions about a topic of interest.

A quantitative approach was adopted for this research because of the nature of the study's research questions. To answer questions relating to the relationship between two or three variables (research questions1-4) quantitative/numerical data is needed [40] to perform correlational analyses. Correlational analyses are aligned with a quantitative approach [43], which lends itself to quantitative data collection, analysis, and interpretation [42]. The research questions for this research can be answered by collecting and analyzing numerical data on the 4th form students' mathematics anxiety, attitude towards mathematics and mathematics achievement. The numerical data collected on the 4th form students regarding their mathematics anxiety, attitudes toward mathematics and mathematics achievement can be analyzed using statistical procedures to determine and describe the relationships among the variables, as well as make predictions (research question 5) about the 4th form population [42]. With quantitative research, large amounts of numerical data can be collected in a minimal time, as a result the findings may be generalized for the 4th form population.

This research was done using a cross-sectional survey research design. A cross-sectional survey research design is a type of quantitative research design in which a survey or questionnaire is administered to a sample or population, at a particular time in study to provide a description of trends, attitudes, or opinions of a population by studying a sample of that population [43, 42]. In this research, a cross-sectional survey design was chosen for two reasons because this design aligns with aspects of the purpose of this research, which is to collect responses from the students at a particular point in time, regarding their mathematics anxiety and attitude towards mathematics. From the responses, the researcher will be able to describe and analyze the relationships between or among their mathematics anxiety, attitude towards mathematics and their mathematics academic achievement; as well as, determining the extent to which their mathematics anxiety and attitude towards mathematics jointly predict the mathematics achievement at a particular point in time [43]. Given that the researcher's aim was to explain and better understand the relationships among the variables at a Particular point in time, a cross-sectional survey design was selected [44]. A second reason is that this design has also been utilized in previous research that has explored the relationship between students' mathematics anxiety and/or students' attitude towards mathematics in relation to their mathematics [45] and so it is appropriate to adopt this

design for the present research.

3.2 Research Context

This research was done in the Turks and Caicos Islands, a non-self-governing British Overseas Territory, which located in the Caribbean, Southeast of the Bahamas archipelago and North of the island of Hispaniola (Haiti and the Dominican Republic) (see Figure 1). There are eight inhabited islands that make up the Turks and Caicos Islands, with Providenciales being the largest among them (see Figure 2).

Map Showing the location of the Turks and Caicos Islands in Reference to the Bahamas

Figure 2

Map of the Turks and Caicos Islands

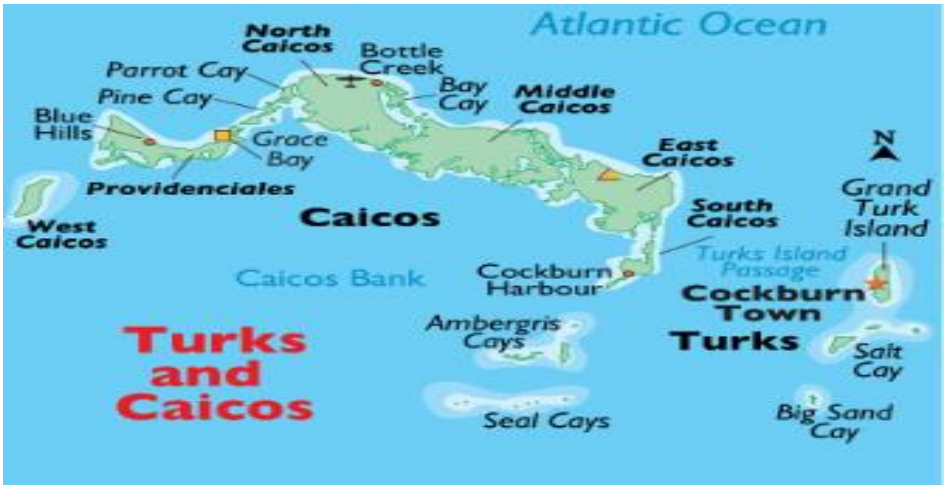

Figure 3

3.3 The Research Site

This research was done at a secondary, co-educational, public school on the island of Providenciales. In the

Turks and Caicos Islands, a public school refers to a primary, secondary or tertiary school that is available to all children, that operates and fully funded by the government and is managed by the Ministry of Education, Youth, Sports and Library Services and the Department of Education, Turks and Caicos Islands education sector plan 2018-2022.

In Providenciales, there are six secondary schools, two of which are public and four are private. As it concerns the two public secondary schools, in Providenciales, one school has students from first to third form (aged 12 – 14 years), while the other has students from fourth to fifth form (aged 15 – 17 years). After the students have completed the third form, they transition to the fourth form in either a public or a private school, if their parents or guardians decide for them to make the transition. This research was done at a public school that has fourth and fifth-four-form students. This school was chosen using a convenient sampling method. According to [44], convenience sampling is a non-random sampling technique that involves choosing what is immediately accessible. This research site was chosen because the researcher is a 4^{th} and 5^{th} form mathematics teacher at the selected school, hence it was more convenient for the researcher to gain access to the school, the parents of the students, the students, and to collect the data for the sample. Additionally, it is the only public secondary school in the settlement to which the researcher resides and has access, making it an appropriate choice for conducting the research. At each grade level, the students are distributed across eight classes at the research site. The distribution of the 4^{th} form students across the eight classes is based on the student's choice of subjects as well as their final academic score on their final mark sheet from their previous school. Based on the criteria, the students are further streamed into two groups; students who will sit the CSEC examinations and the students who will complete the Caribbean Vocational Qualification programme (CVQ). The students that recieve a final average score of 60% - 100% at the previous high school which accommodates 1^{st} – 3^{rd} form, are placed in the General CSEC group, while the students that obtain below the 60% average score are placed in the General Education group. The students in the General Education group are required to complete the CVQ assessments of their choice and they are allowed to sit some CSEC examinations.

The CSEC examinations and the CVQ assessment are examinations administered by the Caribbean Examinations Council (CXC). The Caribbean Examinations Council is a regional examining body that provides examinations for some primary, secondary and post-secondary candidates in Caribbean countries [2].

3.4 Population and Sample

There are 353 students (168 males and 185 females) enrolled in the school. The fourth-form student population consists of 180 students (96 males and 84 females) distributed across eight classes. The fourth form population represents 51% of the total school's population. The fourth form students were invited for the study to maximize the reliability of the study [43] However, the sample consisted of 70 fourth-form students (21 males and 49 females) aged (15 – 16).

3.5 Research Sampling

According to Cohen and his colleagues (2018), the larger the sample size, the greater the reliability is for

quantitative research. The researcher targeted all (n = 180) students since the researcher needed as many students as possible to participate in the study to get a good representation of the population. [42] suggest that online calculators might be useful in determining the required sample size. The 4th form population consists of 84 females and 96 males which represents 51% of the total school's population. Therefore, the least number of students that this study hoped to recruit was 123 students. This represents 68% of the 4th form student population. The sample size was determined using the Raosoft online sample size calculator with 100% of the population proportion. [43] posit that it is important that the sample represents the whole population if it is to be a valid representation of the whole. The researcher invited the entire fourth-form student cohort (N = 180) to participate in the research, however, some were not willing to participate in this research. A total of 70 students participated in this research, 21 males and 49 females. This represents 39% of the 4th form population.

3.6 Data Collection Procedures

The data for this research included students' mathematics achievement scores from their end-of-first-term mathematics examination, their scores from their responses to the mathematics anxiety questionnaire and their scores from their responses to the attitudes toward mathematics questionnaire. The data was collected using an End-of-First-Term mathematics examination and a questionnaire that consisted of three sections. Section A required demographic data from the sample, while Sections B and C are the Modified Abbreviated Math Anxiety Scale (mAMAS) and the Attitude Towards Mathematics Inventory Short Form (ATMI-Short Form), respectively.

3.6.1 Mathematics Anxiety Questionnaire

The Modified Abbreviated Math Anxiety Scale (mAMAS) contains nine positively worded statements that were used to measure how anxious students are when placed in situations involving mathematics. The questionnaire uses a 5-point Likert scale as follows: 1–Low anxiety, 2–Some anxiety, 3–Moderate anxiety, 4– Quite a bit of anxiety and 5–High anxiety. Each participant's overall mathematics anxiety score ranges from a minimum of nine to a maximum of 45.

3.6.2 Attitude Towards Mathematics questionnaire

The Attitude Towards Mathematics Inventory Short Form (ATMI-Short Form) contains 19 statements that were used for measuring students' attitudes toward mathematics. Also, it measures four subscales: mathematics enjoyment; mathematics motivation; self-confidence in mathematics and the perceived value of mathematics. The questionnaire uses a 5-point Likert scale (1- strongly disagree, 2- disagree, 3- undecided, 4- agree, or 5- strongly agree) that scores the students based on their responses. The questionnaire consists of 14 positively worded statements (1 - 9 and 15 - 19) and five negatively worded statements (10 -14). The total score for each participant ranges from a minimum of 19 to a maximum of 95. The electronic questionnaire was administered via Google Forms. The questionnaires were completed in approximately 20 minutes.

Once parental informed consent and child assent had been obtained for students participating in the research, the students were invited to complete the online questionnaire using the link for the questionnaire posted online in

the respective classes through the school's online learning platform 'Microsoft Teams'. The Form 4 mathematics teachers supervised the administration of the questionnaire to alleviate the possibility of students corresponding while completing the questionnaire.

3.6.3 Administration of the Questionnaire

The data for the questionnaires were collected over a period of four days and administered mainly during the students' regular mathematics class hours. At the research site, there are four computer labs which can accommodate a maximum of 25 students. However, one computer lab was utilized because the others were unavailable due to the administering of CSEC examinations. As a result, the classes were invited to the computer lab to complete the questionnaire based on the availability of the lab and when they have mathematics class. They were supervised by their assigned mathematics teacher. The procedure was repeated for the remaining classes, the three days. The literacy levels of the students vary widely and so, the teacher administering the questionnaire, assisted the students who had difficulties reading the instructions and items by reading aloud the instructions for them and reading aloud each question aloud to be able to select the option that best applies to them. The researcher closed the questionnaire link after each class had completed the questionnaire to ensure that students did not complete the questionnaire more than once, also this was to ensure that only the students from the respective class that was present on the day were able to submit their responses.

3.7 Data Collection Instruments

Mathematics Anxiety Questionnaire

For the purposes of this study, the Modified Abbreviated Math Anxiety Scale (mAMAS) [13] which consists of nine items were used to measure how anxious students are when placed in situations involving mathematics. The Abbreviated Math Anxiety Scale (AMAS) questionnaire was originally developed by [20] for measuring mathematics anxiety levels at both the primary and secondary levels [25]. According to [25] , mAMAS provides a valid and reliable Scale for measuring MA in both children and adolescents. In this regard, George and [3] reported excellent test-retest reliability ($r = 0.84$) and high internal consistency (Cronbach's $\alpha = 0.81$).

This questionnaire uses a 5-point Likert scale as follows: 1–Low anxiety, 2–Some anxiety, 3–Moderate anxiety, 4– Quite a bit of anxiety and 5–High anxiety. Each participant's overall mathematics anxiety score ranges from a minimum of nine to a maximum of 45.

3.8 Attitude Towards Mathematics questionnaire

The 19-item Attitude Towards Mathematics Inventory Short Form (ATMI-Short Form) is a well-established scale for measuring students' attitudes toward mathematics. It measures four subscales: mathematics enjoyment; mathematics motivation; self-confidence in mathematics and the perceived value of mathematics. The questionnaire consists of a 5-point Likert scale (1- strongly disagree, 2- disagree, 3- undecided, 4- agree, or 5- strongly agree) that scores the students based on their responses. The instrument consists of 14 positively worded statements (1- 9 and 15-19) and five negatively worded statements (10-14). The total score for each

participant ranges from a minimum of 19 to a maximum of 95. High scores reflect positive attitudes towards mathematics. [44] reported the reliability coefficient of the overall ATMI Short Form instrument as 0.93.

3.9 Mathematics achievement

The students' mathematics achievement was obtained from a teacher-made end-of-first-term examination. The examination assessed the students on mathematical contents covered in the first term of the 2022/23 academic year as well as few contents covered from previous grades. There were two (2) separate end-of-first-term examinations, this is because the students are streamed into two groups; students' who will complete the CSEC mathematics examination and students who will not complete the CSEC mathematics examination (General Ed group). Specifically, for mathematics, six classes are taught using the entire CSEC mathematics syllabus in detail and assessed based on their numeracy level. The other two classes are taught using the same CSEC mathematics syllabus but not thoroughly and are assessed based on their numeracy level. Specific objectives for the examination for both groups of students is collectively decided by the mathematics teachers who teach the group of students. The mathematics examination created for the General Ed students covers fewer objectives when compared to the examination for the students who will sit the CSEC examination.

3.9.1 Reliability and Validity

Validity is affected by the extent to which an instrument measures what it is intended to measure while the reliability of an instrument is its ability to consistently reproduce a certain result [46]. The most common and useful statistic used by researchers to evaluate the reliability of a research instrument is Cronbach's alpha. [46] recommended an alpha range of 0.7- 0.9. In this regard, [45] reported excellent test-retest reliability ($r = 0.84$) and high internal consistency (Cronbach's $\alpha = 0.81$). Therefore, making mathematics anxiety scale a reliable instrument for measuring students' mathematics anxiety. The validity of the instrument has been verified by previous researchers [45].

The construction validity of the mAMAS was determined through confirmatory factor analysis which revealed that the mAMAS had the same structure as the abbreviated math anxiety scale [AMAS] [13]. Regarding the Attitude Towards Mathematics Inventory Short Form (ATMI-Short Form) scale, the alpha score was 0.93. The validity of the instrument has been verified by previous researchers. Confirmatory factor analysis was used to determine the construct validity of the ATMI-Short Form and revealed that it had the same structure as the Attitude Towards Mathematics Inventory scale [ATMI] .

3.9.1 End-of-Term Examination

As it relates to the End-of-Term Examination, the questions were taken from CSEC's past papers. The CSEC examinations are standardized regional exams, therefore the items are valid and reliable for assessing students' knowledge, comprehension and reasoning ability. The Examinations Development and Production Division (EDPD) is responsible for setting and editing examination papers; item analysis; among other tasks (Examinations development and production, 2022). Staff members of the division have graduate-level training and have experience working in measuring and evaluation for a few years. Therefore, making them experts in

their field. Concerning the compilation of the questions for the End-of-term mathematics examination, the mathematics teachers at the research site select questions from the CSEC past papers that align with the objectives of what was taught from the CSEC syllabus. The teachers are all qualified in the field of mathematics, holding at least a bachelor's degree in mathematics and Biochemistry equip them with the knowledge to examine the compilation of the questions on the mathematics examination.

3.9.2 Administration of Exam

The paper-based written examination was administered during the assigned time stated on the school's examination timetable. The duration of the examination was two hours. The Form 4 mathematics teachers supervised the administration of the examination in order to alleviate the possibility of students corresponding while completing their examination. The respective teachers also marked their students' papers and recorded the scores on the school's learning management system. A mark sheet (grade sheet) was produced for each student on December 14, 2022, the last day of the first academic term. The final score for the students' end-of-first-term examination was collected from their mark sheets in June 2023 by their respective teachers. Students' grades ranged from 0% to 100% where 60% is the school's pass mark. Letter grades are also used along with the mark's description ranging from A to F.

The research site's grading system and marks description ranging from A to F.

Table 4

Academic Scale		
Grade point %	Letter description	Description
85 - 100	A	Excellent
70 - 84	B	Very Good
60 - 69	C	Good
50 - 59	D	Fair
40 - 49	E	Poor
Below 40	F	Very Poor

4.1 Methods of Data Analysis

The data analysis for this study consists of two phases: Preliminary Data Analysis and Main Study Data Analysis. In this study, statistical tests were carried out using a computer program called IBM Statistical Package for the Social Sciences (SPSS) version 25.0.

4.2 Preliminary Data Analysis

Before completing the main analysis in this study, preliminary data analysis was carried out to test normality,

linearity and homoscedasticity assumptions. According to [40], a verification of the normality, linearity and homoscedasticity assumptions should be done before conducting statistical analyses of any data. This is to ensure there are no violations of the assumptions, which are the key assumptions of parametric tests. Assessing normality means obtaining the skewness and kurtosis values, which is a key assumption for determining which statistical tests (parametric or non-parametric) are appropriate for the following analyses related to the research questions [40]. Reference [47] posit that graphical and numerical methods, such as skewness, kurtosis, and histogram can be used to test the normality of continuous data when the sample size (n) is at least 50. To test for normality, a histogram showing the distribution of students' mathematics anxiety scores, and a histogram showing the distribution of students' attitudes toward mathematics scores were created, this is a visual representation of the data collected, showing whether the graph is symmetrical, that is, a bell-curved with the smaller frequencies at the extremes. Similarly, if the **Sig.** value of the Shapiro-Wilk Test is greater than 0.05 [40], normality assume. If it is below 0.05, the data significantly deviates from a normal distribution. To test linearity, scatterplot was utilized by the researcher. In a scatterplot, the relationship between the variables should be depicted as a roughly straight line to demonstrate linearity. The test for homoscedasticity assesses the assumption of equal or similar variance in different groups being compared. Based on the results obtained the data was analyzed using both parametric and non-parametric statistics (See Presentation of Results).

4.3 Main Data Analysis

For the analysis of data, the researcher used Correlational statistics to analyze the relationship among students' mathematics anxiety, attitudes toward mathematics and their mathematics achievement (See Table 5). A histogram showing the distribution of students' mathematics anxiety scores, and the distribution of students' attitudes toward mathematics scores were generated, this is a visual representation of the data collected. Table 5 shows the parametric and non-parametric tests that were performed based on the research questions. *Parametric and non-parametric tests based on research questions*

Table 5

Research Question	Parametric Test	Non-parametric Test
1. What is the relationship between 4th form secondary students' Mathematics Anxiety and their mathematics achievement?	Pearson's correlation	Spearman's rank-order correlations
2. What is the relationship between 4th form secondary students' Attitudes toward mathematics and their mathematics achievement?		
3. What is the relationship between 4th form secondary students' mathematics anxiety and attitudes toward mathematics?		
4. What are the relationships among 4th form secondary students' mathematics anxiety, attitude towards mathematics and their mathematics achievement?		Spearman's rank-order correlations
5. To what extent will 4th form students' mathematics anxiety and attitude toward mathematics jointly predict their mathematics achievement?		Not applicable

4.4 Mathematics Anxiety

The MA survey contains nine items with a 5-point Likert scale. Prior to analyzing the data for research questions relating to mathematics anxiety, one of the following scores were assigned to the student response for each item: 1–Low anxiety, 2–Some anxiety, 3–Moderate anxiety, 4–Quite a bit of anxiety, 5–High anxiety. The scores were assigned to each of the nine responses relating to each item and were added to obtain the total MA score. The total MA score ranges from a minimum of nine to a maximum of 45. Students' total mathematics anxiety scores were used three groups as follows: low anxiety (9 - 20), moderate anxiety (21 - 32), and high anxiety (33- 45). These groups were obtained using quartiles. The MA scores are continuous data.

4.5 Attitudes Towards Mathematics

The attitudes toward mathematics scale contains 19 items. Before analyzing the data for research questions relating to students' attitudes toward mathematics, one of the following scores, 1-strongly disagree, 2-disagree, 3-undecided, 4-agree, or 5-strongly agree were assigned to the student response for each positive item (1- 9) and (15- 19). Negative items (10 - 14) were scored reversely. The scores from each of the 19 items were summed to obtain a total ATM score. The total ATM scores have minimum and maximum values of 19 and 95, respectively. Students' total ATM scores were used to assign them to one of two groups' negative attitudes towards mathematics (19 - 56) and positive attitudes towards mathematics (57 - 95). These groups were obtained using a median split. The ATM scores are continuous data.

4.6 End of First Term Mathematics Achievement Scores

Students' mathematics achievement scores were assigned into two groups. The higher scores (60 -100%) were regarded as high mathematics achievement and the lower scores (0-59%) were regarded as low mathematics achievement. The scores were divided using the grading system of the research site where the school's pass mark is 60%. The final end-of-term examination scores were calculated for the General Education students and the General CSEC students. For the General Education students, the paper consisted of two sections, section one consisted of 30 multiple choice questions, and Section two consisted of four essay type questions. The marks for each question were added to give a total of 70 marks. The total mark percentage students received was obtained as shown below:

$$\frac{\text{the mark/s obtained total marks}}{(70)} \times 100\% = \text{Total mark as a percentage}$$

Final score: Total percentage mark for the paper

For the General CSEC students, the mathematics examination consisted of one paper. The paper consisted of three parts, section I which consisted of 20 multiple choice questions each with a worth of one mark, section II which consisted of five fills in the blanks and section III which consisted of six structured questions, with a total of 30 marks, the paper was marked out of 55. The total mark percentage students received was then calculated

4.7 Ethical Considerations

To satisfy the ethical standards appropriate for conducting research, the following actions were carried out prior to administering the informed consent forms, assent form, and questionnaire. The researcher first sought and obtained permission from the University of the West Indies Mona Campus Research Ethics Committee (MCREC) to undertake the research. Upon gaining institutional approval, the researcher sought and obtained permission from the principal to carry out the research at the selected research site. Informed consent, anonymity, and confidentiality were the three key ethical concerns that were addressed in this research. Regarding the informed consent forms, teachers at the research site were given an online informed consent form to review and indicate their willingness to participate in the research. Additionally, parents/guardians were given an online informed consent form to review and indicate their willingness for their child/ward to participate in the study. Parents and guardians who were unable to finish the informed consent form online were given a hard copy of the form. Once parents give consent, the students are given an online assent form to review and show their willingness to participate in the study. Students' personal data, such as their names, were removed and replaced with numbers to maintain anonymity. To ensure confidentiality, the respondents' data, which include end-of-first-term mathematics grades and responses to the questionnaire were kept in password-protected electronic files on a password-protected computer. The data was only accessible to the researchers undertaking the present research.

5. Presentation of the Results

The following section provides information relating to the findings of the preliminary data analysis that was carried out (normality, linearity and homoscedasticity) and the main data analysis that was conducted.

5.1. Preliminary Data Analysis Results

The Test for Normality

Based on the results obtained, there were no violations of normality for students' Mathematics Anxiety and students' Attitude Towards Mathematics. However, students' Mathematics academic achievement score violated that assumption for normality. In a normal distribution, a bell-shaped curve is shown in the histogram in which the greatest frequency of scores is in the middle with smaller frequencies towards the extremes [40]. In terms of the skewness and kurtosis values, [40] posits that the skewness and kurtosis statistic values should be less than +1.0 and greater than -1.0 for the distribution to be considered normal. As it relates to students' Mathematics Anxiety, Attitude Towards Mathematics and Mathematics Academic Achievement the skewness values were close to 0 (within the range -1.0 to +1.0) showing that the distribution of scores is not skewed. By considering the kurtosis values, students' Mathematics Anxiety and Attitude Towards Mathematics were within the range (-1.0 to +1.0) showing that the distribution is normal. However, this was not the same for students' Mathematics academic Achievement; the Kurtosis value was less than -1.0 which means that the distribution is platykurtic (flatter than normal).

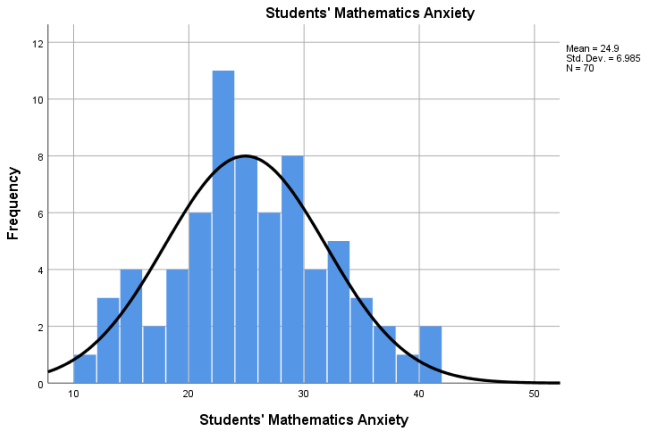

Figure 4: Students' mathematics Anxiety

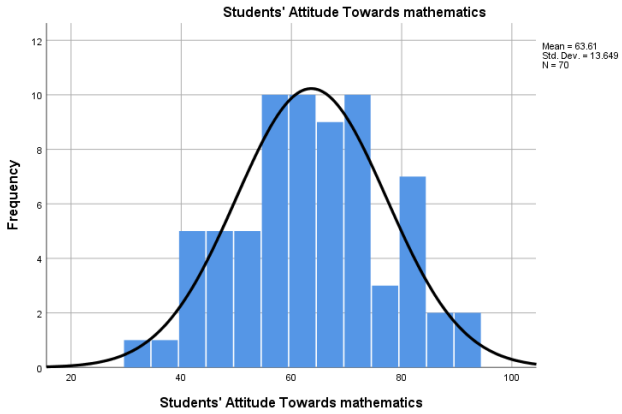

Figure 5: Students Attitude Towards Mathematics

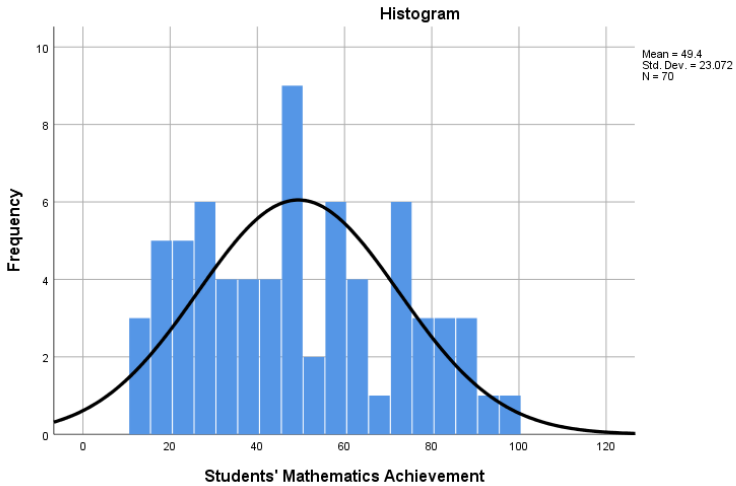

Figure 5

Table 5

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Students' Mathematics Achievement	.095	70	.199	.960	70	.025
Students' Mathematics Anxiety	.061	70	.200*	.987	70	.658
Students' Attitude Towards mathematics	.056	70	.200*	.986	70	.647

*. This is a lower bound of true significance.

a. Lilliefors Significance Correction

Table 6: Analysis of data

Descriptives

			Statistic	Std. Error
Students' Mathematics Anxiety	Mean		24.90	.835
	95% Confidence Interval for Mean	Lower Bound	23.23	
		Upper Bound	26.57	
	5% Trimmed Mean		24.83	
	Median		24.50	
	Variance		48.787	
	Std. Deviation		6.985	
	Minimum		11	
	Maximum		41	
	Range		30	
	Interquartile Range		9	
	Skewness		.121	.287
	Kurtosis		-.338	.566
Students' Attitude Towards mathematics	Mean		63.61	1.631
	95% Confidence Interval for Mean	Lower Bound	60.36	
		Upper Bound	66.87	
	5% Trimmed Mean		63.68	
	Median		63.50	
	Variance		186.298	
	Std. Deviation		13.649	
	Minimum		32	
	Maximum		91	
	Range		59	
	Interquartile Range		17	
	Skewness		-.079	.287
	Kurtosis		-.515	.566
Students' Mathematics Achievement	Mean		49.40	2.758
	95% Confidence Interval for Mean	Lower Bound	43.90	
		Upper Bound	54.90	
	5% Trimmed Mean		48.98	

	Median	47.50	
	Variance	532.330	
	Std. Deviation	23.072	
	Minimum	13	
	Maximum	100	
	Range	87	
	Interquartile Range	44	
	Skewness	.229	.287
	Kurtosis	-1.004	.566

Table showing analysis of data continue

5.2 Test for linearity

Linearity is assumed if the scores in a scatterplot between two variables are shown in a roughly straight line [40]. Based on the results obtained, the assumption for linearity between students Mathematics Anxiety and Mathematics Achievement were violated. However, there was no violation of the linearity assumption between students Mathematics Anxiety and Attitude Towards Mathematics, and Attitude Towards Mathematics and Mathematics Achievement. This can be observed in the way the dots are converging together and the roughly straight line.

5.3 Test for linearity

Linearity is assumed if the scores in a scatterplot between two variables are shown in a roughly straight line (Pallant, 2016). Based on the results obtained, the assumption for linearity between students Mathematics Anxiety and Mathematics Achievement were violated. However, there was no violation of the linearity assumption between students Mathematics Anxiety and Attitude Towards Mathematics, and Attitude Towards Mathematics and Mathematics Achievement. This can be observed in the way the dots are converging together and the roughly straight line.

Table 7: ANOVA analysis

			Sum of Squares	df	Mean Square	F	Sig.
Students' Mathematics Achievement * Students' Mathematics Anxiety	Between Groups	(Combined)	15160.258	27	561.491	1.093	.390
		Linearity	1201.594	1	1201.594	2.340	.134
		Deviation from Linearity	13958.664	26	536.872	1.045	.439
	Within Groups		21570.542	42	513.584		
	Total		36730.800	69			

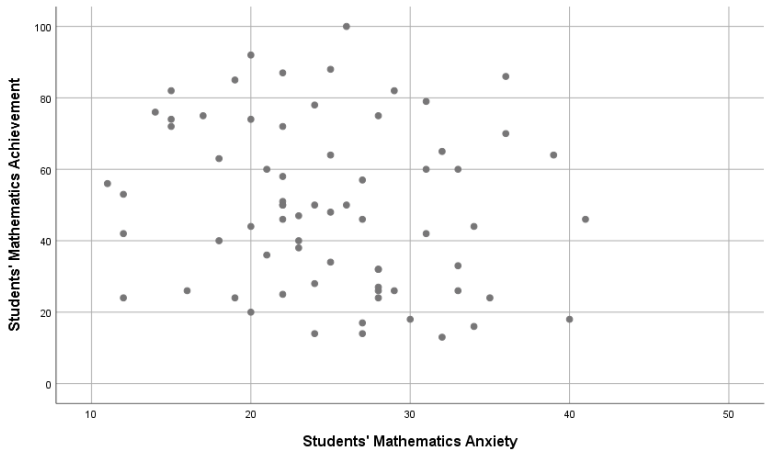

Figure 6: Students Mathematics Aniexty against students mathematics Achievements

Table 8: Anova Data

			Sum of Squares	df	Mean Square	F	Sig.
Students' Mathematics Achievement * Students' Attitude Towards mathematics	Between Groups	(Combined)	25090.633	41	611.967	1.472	.143
		Linearity	2775.223	1	2775.223	6.676	.015
		Deviation from Linearity	22315.410	40	557.885	1.342	.209
	Within Groups		11640.167	28	415.720		
	Total		36730.800	69			

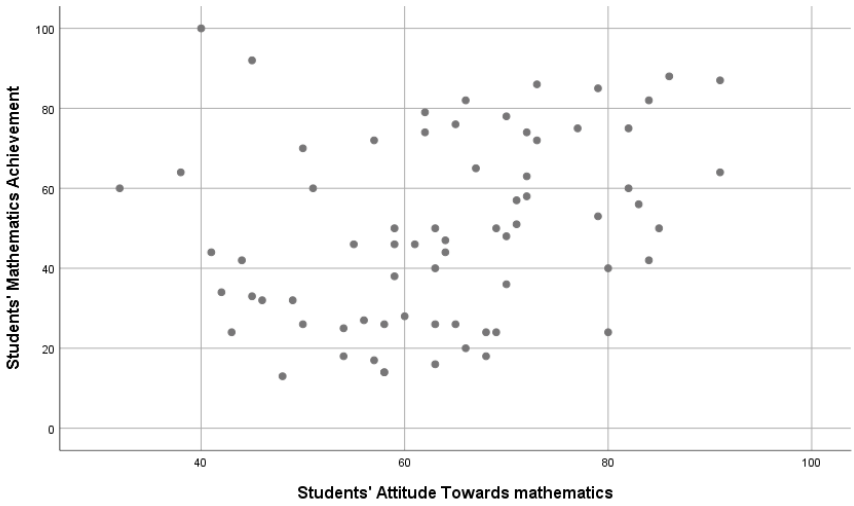

Figure 7: Students' Attitude towards Mathematics against Students Mathematics Achievement

Table 9: showing ANOVA Value

			Sum of Squares	df	Mean Square	F	Sig.
Students' Mathematics Anxiety * Students' Attitude Towards mathematics	Between Groups	(Combined)	2215.550	41	54.038	1.315	.225
		Linearity	1047.047	1	1047.047	25.477	.000
		Deviation from Linearity	1168.503	40	29.213	.711	.841
	Within Groups		1150.750	28	41.098		
	Total		3366.300	69			

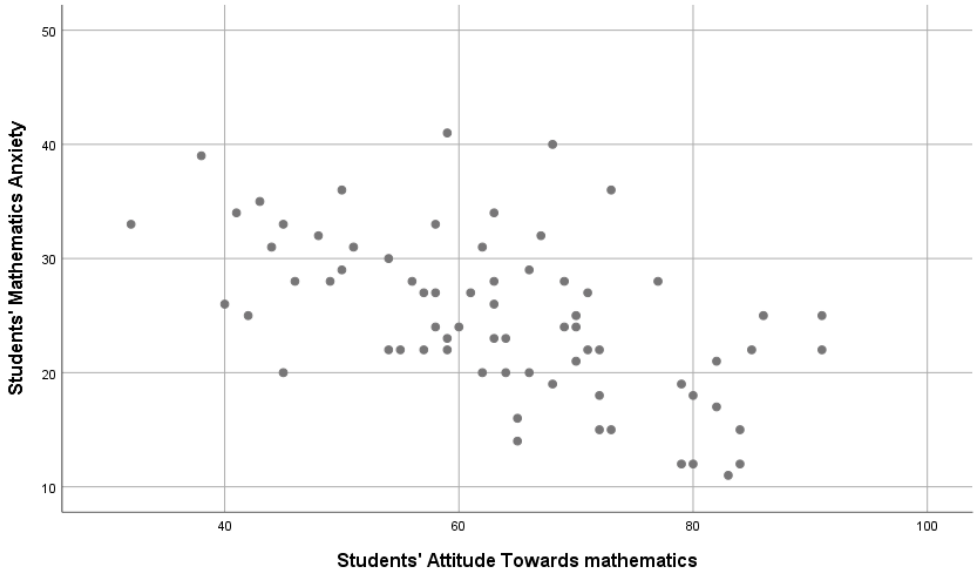

Figure 8

5.4 Test for homoscedasticity

The test for homoscedasticity was used to assess the assumption of equal or similar variance in different groups being compared. Based on the output data obtained, the assumption for homoscedasticity was violated (See Appendix). This can be seen as the spread of the residuals are not the constant moving along the horizontal line going through zero.

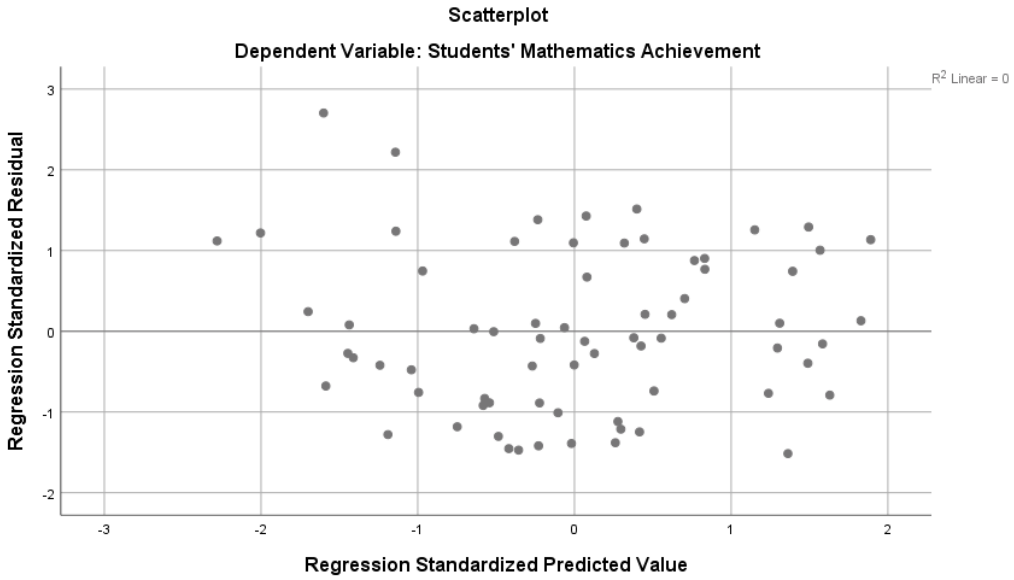

Figure 9

Given that the preliminary analysis did not meet all the assumptions (normality, linearity and homoscedasticity) for parametric statistical analysis, the data will be analyzed using non-parametric statistic. Therefore, this means that the statistical analysis for research question 5 (To what extent will 4th form students' mathematics anxiety and attitude toward mathematics jointly predict their mathematics achievement?) is not applicable.

6. Main Data Analysis Results

Research questions

1. What is the relationship between 4th form high school secondary students' mathematics anxiety and their mathematics academic achievement?

The spearman rho correlation coefficient was generated for students' mathematics anxiety and their mathematics achievement. According to [44], there is a small negative and non-significant correlation that exists between mathematics anxiety scores and mathematics achievement (rho = -.205, n=70, p = 0.089), with high levels of mathematics anxiety associated with low mathematics achievement. This means that as students' mathematics anxiety increases their mathematics achievement decreases (see Table 6).

Table 6: Indicating correlation data between students' mathematics anxiety and students' mathematics achievement

				Students' Mathematics Anxiety	Students' Mathematics Achievement
Spearman's rho	Students' Anxiety	Mathematics	Correlation Coefficient	1.000	-.205
			Sig. (2-tailed)	.	.089
			N	70	70
	Students' Achievement	Mathematics	Correlation Coefficient	-.205	1.000
			Sig. (2-tailed)	.089	.
			N	70	70

Research Question

2. What is the relationship between 4th form high school secondary students' attitude towards mathematics and their mathematics achievement?

The spearman rho correlation coefficient was generated for students' attitude towards mathematics and mathematics achievement. According to [43], there is a medium positive and significant correlation between mathematics anxiety scores and students' mathematics achievement (rho =.336, n=70, p = 0.005), with high levels of students' attitude towards mathematics associated with high mathematics achievement. This means that as students' attitude towards mathematics increases, their mathematics achievement also increases (see Table)

Table 7: indicating correlation between students' attitude towards mathematics and students' mathematics achievement.

				Students' Attitude Towards mathematics	Students' Mathematics Achievement
Spearman's rho	Students' Attitude Towards mathematics		Correlation Coefficient	1.000	.336**
			Sig. (2-tailed)	.	.005
			N	70	70
	Students' Achievement	Mathematics	Correlation Coefficient	.336**	1.000
			Sig. (2-tailed)	.005	.
			N	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

Research question

2. What is the relationship between 4th form secondary students' mathematics anxiety and their attitude towards mathematics?

Pearson's correlation coefficient was generated for students' mathematics anxiety and attitude towards mathematics. According to [43], there is a large negative and significant correlation between mathematics anxiety scores and students' attitude towards mathematics (rho = -.558, n=70, p < 0.001), with high levels of mathematics anxiety associated with low attitude towards mathematics. This means that as students' mathematics anxiety increases their attitude towards mathematics decreases (see Table 8).

Table 8

Correlations

		Students' Mathematics Anxiety	Students' Attitude Towards mathematics
Students' Mathematics Anxiety	Pearson Correlation	1	-.558**
	Sig. (2-tailed)		.000
	N	70	70
Students' Attitude Towards mathematics	Pearson Correlation	-.558**	1
	Sig. (2-tailed)	.000	
	N	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

Research Questions

4. What are the relationships among 4th form secondary students' mathematics anxiety, attitude towards mathematics and their mathematics academic achievement?

The spearman rho correlation coefficient was generated for students' mathematics anxiety, attitude towards mathematics and their mathematics academic achievement. Based on the table, there is a relationship among the three variables. This statistical technique revealed a small negative and non-significant correlation between mathematics anxiety scores and mathematics achievement (rho = -.205, n =70, p = 0.089), a medium positive and significant correlation between mathematics anxiety scores and High school students mathematics academic achievement (rho =.336, n =70, p = 0.005), and lastly, a large negative and significant correlation between mathematics anxiety scores and students attitude towards mathematics (rho = -.570, n =70, p < 0.001) (Cohen, 1988). Although there is a relationship among the three variables, it is important to note that there is a stronger

correlation between students' mathematics anxiety and students' attitude towards mathematics (see Table 9).

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