CJED
CARIBBEAN JOURNAL OF EDUCATION AND DEVELOPMENT

Exploring Mathematics Anxiety and Achievement: Insights from a Coeducational Secondary School in the Turks and Caicos Islands

Christina Anderson-Waugh, Lois George
The University of the West Indies, Mona

Abstract

Mathematics anxiety (MA) is currently recognised as a significant area of study within the field of mathematics education. This cross-sectional survey research explored the prevalence of MA, its impact on mathematics achievement, and resulting MA-mathematics achievement profiles among 70 Form 4 students (aged 15–16) in a coeducational secondary school in the Turks and Caicos Islands (TCI). Data were collected using the Modified Abbreviated Math Anxiety Scale (mAMAS) and a mathematics achievement test. Descriptive statistics, ANOVA, and Spearman Rank correlations were employed for analysis. Results indicated mostly moderate anxiety levels, with 16% reporting high MA. There were no significant differences in mathematics achievement across different MA levels, and a small, non-significant negative correlation was observed between MA and achievement. Various profiles emerged, highlighting a complex relationship. Further research is warranted to explore the relationship between MA and mathematics achievement, as well as other factors that may more strongly influence students' mathematics achievement than MA. These foci may be helpful to educational stakeholders such as teachers and policymakers in planning to improve student mathematics achievement in the TCI.

Keywords: mathematics anxiety, mathematics achievement, secondary school

Background

In the Turks and Caicos Islands (TCI), mathematics examination results have consistently been poor, both internally and externally, for at least a decade ("CSEC maths passes down but English pass rate up", 2019; Statistics Authority Turks and Caicos Islands, 2017; Taylor, 2023). Given that passing mathematics is crucial for the future education and employment opportunities of many students, this persistent underperformance is a significant concern for educational stakeholders. To address this issue, the TCI Ministry of Education has implemented various strategies, such as adopting Singaporean mathematics curricula and conducting professional development sessions for teachers (Malcolm, 2023). However, the issue of unsatisfactory mathematics performance persists. While many factors influence individual mathematics achievement, no empirical research has been conducted on this topic in TCI to date. This study, therefore, aims to fill that research gap and on this basis is significant.

Among the myriad factors linked to mathematics achievement, studies have revealed that mathematics anxiety (MA) has a major influence on a person's mathematics engagement and achievement (Beilock & Maloney, 2015;

Submitted 27 March 2024
Accepted 2 August 2024
Electronically published 5 September 2024

https://doi.org/10.46425/cjed101023567

Caribbean Journal of Education and Development,
Vol. 1 No. 2 2024
 • ISSN 0799-6977

Caviola et al., 2022). MA is a dynamic construct (Rubinsten et al., 2018) that conveys the notion that people experience varied feelings of tension, helplessness, and fear when engaged in mathematics-related activities, whether in daily life or academic situations (Ashcraft, 2002; Ramirez et al., 2018; Richardson & Suinn, 1972). This definition of MA has been adopted for this research.

In recent years, MA has drawn considerable interest and has been recognised as a significant area of study in the field of mathematics education (Barroso et al., 2021; Radević & Milovanović, 2023). Although substantial research on the topic of MA exists, most studies have been conducted in developed countries or the Global North (Cipora et al., 2022). This disparity is not wholly surprising, as it is common knowledge that researchers in the developed world have greater access to research funding; the most recent scholarly literature on which to base their work; as well as knowledge, expertise, and current innovations in research compared to their counterparts in the Global South (Mahajan et al., 2023). Therefore, it is understandable that researchers in developed countries are able to undertake a larger number of studies (many of which are large-scale); publish in top journals; and drive the agenda as to what is current and important in a research field. Furthermore, Nakamura et al. (2023) note that "research produced by the Global South is often seen as peripheral, and Southern researchers struggle to find their expertise recognised by the Global North" (p. 1). A cursory inspection of the reference list in research focused on MA confirms that few studies from research undertaken in developing countries are referenced in work published by Northern researchers.

There has also been a greater recognition and discussion of (as well as emphasis on) the issues of diversity and inclusion in research (Maas et al., 2021). In this regard, Barroso et al. (2021) point out that studies on MA involving samples from developing countries have seen a rise in recent years. Nevertheless, in certain regions, there remains room for additional scholarly investigation. For instance, the Caribbean region and adjacent territories such as the Bahamas and the Turks and Caicos Islands (TCI) have received limited attention in studies concerning MA. Previous research efforts in the Caribbean and its environs have primarily focused on specific demographic groups, including primary and lower secondary Jamaican students (George & Dowdie, 2021; Mitchell & George, 2022), preservice teachers from Trinidad (Atwell-Chin Hong, 2021; Jaggernauth & Jameson-Charles, 2015), and a national sample of Belizean students and teachers (Richland et al., 2020).

Cultural context has been deemed to be an important factor in mathematics education in general (Presmeg, 2007) and MA in particular (Richland et al., 2020). In this regard, Richland et al. (2020) note in relation to the Latin American and Caribbean (LAC) countries that participated in the 2012 Programme for International Assessment (PISA):

> The nature of the relationships between mathematics anxiety and performance may be culturally specific. The LAC included in the OECD data collection were among the highest internationally in mathematics anxiety, and the lowest in overall achievement, suggesting that mathematics anxiety may be an important consideration in addressing achievement in this region (p. 2).

The longstanding issue of unsatisfactory mathematics achievement in the TCI, the small number of studies on MA conducted in the Caribbean and neighbouring jurisdictions to date, and the need for inclusion in research underscore the significance of the current research which involves a sample of upper-secondary students from the TCI, a developing country. While research undertaken in the developed world may yield similar results to that of samples and localities in developing and underdeveloped countries, this will only emerge when research in these contexts is conducted and published.

The current study is also significant since students at the upper secondary school level have been the focus of only a few studies internationally (Asikhia, 2014; Demedts et al., 2022; Gopal et al., 2020; Luu-Thi et al., 2021; Yáñez-Marquina & Villardón-Gallego, 2017). The studies involving this student group have also had diverse foci, such as the relationship to self-efficacy, validating a research instrument, and exploring an intervention for mathematics-anxious students—and there is scope for further investigation to enhance the existing complement of research. These considerations affirm that the current research, in an underrepresented developing country context and sample, is both noteworthy and timely.

Stemming from the previously mentioned research gaps, this study aims to investigate the distribution of MA, the relationship between MA and mathematics achievement, and the individual MA–mathematics achievement profiles that emerge from the data. Exploring these research concerns in underrepresented contexts such as the TCI, is an essential first step in understanding the MA phenomenon in that context, and so this research has both international and local/regional relevance. By establishing the distribution of MA in the sample, we can better understand the scope of the problem and its potential impact on academic performance. Additionally, this research serves as a baseline for future research and intervention efforts aimed at addressing the issue of MA. Furthermore, while the relationship between MA and mathematics achievement has been extensively investigated, most of the inquiries use analyses that provide only an aggregate, seemingly uniform portrait of the data. While this general result is beneficial, Ramirez et al. (2018) note that "as an individual-difference trait, math anxiety is not something researchers can systematically manipulate" (p. 148). Therefore, an examination of individual student data in the development of profiles of MA-mathematics achievement could also be instructive to researchers and practitioners in understanding the MA-mathematics achievement link and developing interventions. This exploration may further uncover the dynamic and nuanced connection between the variables of MA and mathematics achievement and add another dimension to the scholarly research in this domain.

The research questions, therefore, are:

1. What is the distribution of MA levels (low, moderate, and high) among the Form 4 students?
2. Is there a statistically significant difference in the mathematics achievement of Form 4 students who report low, moderate, and high levels of MA?
3. What is the relationship between Form 4 secondary students' MA and their mathematics achievement?
4. What profiles of MA and mathematics emerge from the sample data?

Given the large body of prior research on the incidence of MA and the relationship between MA and mathematics achievement, we hypothesise that most students in this sample would exhibit moderate anxiety and that the percentage of students self-reporting high anxiety would fall between 6 and 15%.

Literature Review

Prevalence of Mathematics Anxiety

Varying estimates of MA prevalence have been reported at the secondary school level across different jurisdictions. In this regard, Cipora et al. (2022) point out that measuring MA using diverse questionnaires and the absence of clearly defined criteria for identifying individuals with high MA hinder a definitive conclusion regarding prevalence. Dowker et al. (2016) also opined that disparities in the prevalence of MA may depend on the sample involved in the study. Additionally, Presmeg (2007) asserted that culture affects how mathematics is taught and learned; as a result, mathematics is a cultural product. Therefore, the findings obtained from one locality may differ in another. Nevertheless, finding the prevalence of a phenomenon is an important starting point for populations and localities which have not been the focus of extensive research.

Most studies used valid and reliable self-report scales to obtain MA measures. When survey data were used for data collection, scores were typically divided into three or four categories, which represent levels of MA ranging from low to high. For example, in research conducted in Jamaica, in the Caribbean region, George and Dowdie (2021) explored the prevalence of MA among 467 secondary school students. When three groups (low, moderate, and high) were used, most students (n=236) reported moderate levels of MA, and approximately 11% of the students fell in the category of high MA. Zakaria et al.'s (2012) study involved 195 secondary students (Form 4) from Malaysia and categorised MA using three MA levels. They found approximately equal numbers of students (n=65, 66, 64) in each of the three MA bands, and approximately 33% of the sample experienced high MA. This result suggests that MA was not normally distributed for the sample as many psychological constructs/variables are (Mann, 2020). The results of Zakaria et al. (2012) differed considerably from that of the Jamaican population, but aligned with that of a study involving 367 Kenyan secondary school students (Khatoon & Mahmood, 2010). They found that 34.3% of their sample reported high MA. In their study, MA was measured using an adapted 14-item Mathematics Anxiety Scale created by the researchers.

The 2012 Programme for International Student Assessment (PISA) reports another distribution of MA among secondary school students. It found that approximately six out of every ten students in high school contend with the issue of high MA (Organization for Economic Co-operation and Development [OECD], 2013). PISA 2012 involved 65 countries worldwide. PISA's approximation falls well outside of Ashcraft et al.'s (2007) theoretical estimation that 17% of a given population would exhibit high levels of MA when assuming a normal distribution of MA scores.

Some studies deviate from using three or four MA categories to explore prevalence. For example, Moyo (2023) focused on exploring individual items within the scale, which revealed that many of their Zimbabwean sample experienced high MA although a specific aggregate percentage was not presented.

The literature reviewed confirms that there does not appear to be a consensus relating to the prevalence of MA. However, large numbers of students at the secondary school level self-report high MA. One reason for this may be that students are introduced to increasingly challenging topics in mathematics at the secondary school level, which in turn impacts the mental and emotional aspects of their well-being (Luu-Thi et al., 2021; Termizi & Mahmud, 2022). Gopal et al. (2020) suggested that students' low mathematics self-efficacy was a key factor related to their high MA.

In terms of the differences in students' mathematics achievement based on their MA level, very few studies have focused on this concern. Some studies have reported statistically significant differences in MA based on achievement levels (Al Mutawah, 2015; Devine et al., 2018; Lee, 2009; Roos et al., 2015; Zakaria et al., 2012). For example, Zakaria et al's. (2012) study found that students' mathematics achievement significantly differed by MA levels ($F = 35.20$, $df = 2, 194$, $p<0.05$). The result showed that students who exhibit low levels of anxiety are high achievers, while those who exhibit high levels of anxiety are low-achieving students. The authors opined that this disparity may be due to high achievers having "a strong understanding of mathematics and more confidence than low achievers" (p. 1831).

Mathematics Anxiety and Mathematics Achievement

Despite the educational level and age group, studies conducted on students' MA and their mathematics achievement have revealed that there is a link between the variables, with most studies reporting a negative correlation between MA and their mathematics achievement (Foley et al., 2017; Namkung et al., 2019; Termizi & Mahmud, 2022). This correlation means that students with lower mathematics achievement levels showed higher MA and vice versa.

Termizi and Mahmud (2022) conducted a quantitative study which investigated the relationships between Form 4 students' MA 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, Malaysia. The results revealed that there was a weak and non-significant negative correlation ($r = -.23$) between the two variables. The results also revealed that the students who perceived themselves to be low achievers had the highest levels of anxiety. Similarly, data from the 2012 Program for International Student Assessment (PISA), which tested the mathematics academic achievement of 15-year-olds worldwide, showed that in 63 of the 64 education systems that participated in this assessment, MA was negatively related to mathematics achievement (OECD, 2013). These correlations support the findings of Namkung et al.'s (2019) meta-analysis study, which found significant, moderate negative correlations ($r = -.36$) between MA and achievement for secondary school students.

The association between students' MA and mathematics achievement has also been linked to a positive correlation, which is in contrast to the usual findings. In a recent study involving upper secondary school Vietnamese students, Luu-Thi et al. (2021) found a significant, weak positive correlation between the level of MA and mathematics achievement ($r = 0.064$, $p < 0.05$).

Frameworks Linking Mathematics Anxiety and Mathematics Achievement

Three frameworks have been used to present the relationship between mathematical achievement and MA: the Deficit Theory, the Cognitive Interference Theory and the Reciprocal Theory (which combines the concepts of the Deficit and Cognitive Interference theories). The Cognitive Interference or Disruption model is the most widely held theory in the field (Ramirez et al., 2018). It posits that MA, especially at high levels, negatively influences mathematics achievement by temporarily reducing the working memory needed for an individual to engage successfully in mathematics activities/problems (Ashcraft & Kirk, 2001; Justicia-Galiano et al., 2017). Working memory refers to the brain's ability to temporarily hold and manipulate a small amount of information needed for a given cognitive task (Baddeley et al., 2014).

The Deficit or Reduced Competency Theory contends that past experiences with low mathematics achievement and memories of those experiences cause future MA to be higher (Carey et al., 2016; Maloney, 2016). Another dimension to this is that students who have reduced mathematics abilities avoid mathematics tasks such as homework and classes, thereby losing opportunities to improve their mathematics knowledge and skills (Hembree, 1990). Ramirez et al. (2018) state that this avoidance may exacerbate their math skill deficits and contribute to MA.

According to Carey et al. (2016), there is a bidirectional association between mathematical achievement and MA: as MA rises, math achievement falls, and vice versa. Regardless of the theoretical stance that a researcher adopts, there is a consensus that a robust relationship exists between students' MA and their mathematics achievement.

Methods

Sample

This research adopted a quantitative, survey approach to examine different elements of MA and its relationship with mathematics achievement. Non-probability, convenient (volunteer) sampling was used in selecting the research sample, which consisted of 70 students (29 males and 41 females) aged 15–16 years. The researchers invited all the Form 4 students ($N = 180$) to participate in the study. However, we received written parental informed consent and child assent from approximately 39% of the Form 4 students at the research site. The small sample size restricted the generalisability of the findings to the broader Form 4 student population, and those who volunteered may have possessed specific characteristics. Despite this research limitation, this study contributes to the limited body of studies conducted in the Caribbean region. The researchers were granted institutional ethical approval to undertake the research.

Research Context

This research was conducted in Providenciales TCI, which is a non-self-governing British Overseas Territory Southeast of the Bahamas archipelago and North of the island of Hispaniola (Haiti and the Dominican Republic). Eight inhabited islands comprise the TCI, with Providenciales being the largest among them.

The Research Site

This research was conducted at a coeducational secondary public school on the island of Providenciales. In the TCI, a public school refers to a primary, secondary, or tertiary school that is available to all children; operates with the aid of government funds; and is overseen by the Ministry of Education, Youth, Sports and Library Services and the Department of Education (Ministry of Education, Youth, Sports & Library Services [Turks and Caicos Islands], 2018).

In Providenciales, there are six secondary schools, two of which are public and four private. Regarding the two public secondary schools in Providenciales, one school has students from Forms 1-3 (aged 12–14 years), while the other has students from Forms 4-5 (aged 15–17 years). After completing Form 3, students transition to Form 4 in either a public or a private school. The researchers were interested in investigating elements of MA in a sample enrolled in upper secondary school. Therefore, only one public school was available as a possible research site. The researchers were permitted to undertake the research in this institution.

Data Collection

Mathematics Anxiety

The Modified Abbreviated Math Anxiety Scale (mAMAS) is a valid and reliable instrument for measuring MA in both children and adolescents (Carey et al., 2017). It comprises nine items with 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 (see Appendix 1). The mAMAS was administered electronically over 4 days to the respondents by their assigned mathematics teacher via Google Forms during the students' regular mathematics class hours.

Mathematics Achievement

A teacher-constructed end-of-term mathematics examination consisting of objective-type and constructed-response items was used to measure students' mathematics achievement. Therefore, for this research, mathematics achievement were the scores students obtained on this test. The test items were based on the mathematics content taught in Term 1 of the academic year in which the research was conducted. The constructed-response items were sourced from past Caribbean Secondary Education Certificate (CSEC) mathematics examinations offered by the Caribbean Examinations Council (CXC).

The CXC is an examination board that conducts examinations and awards certificates and diplomas based on the results of these examinations in 16 Caribbean countries. Secondary school students typically take the CSEC examinations at the end of high school. These examinations are standardised and have been long established to be valid and reliable for assessing students' mathematics knowledge, comprehension and reasoning ability (Griffith, 2015). For the 60 objective-type items, to establish content validity, a table of specifications was used in the development of the test. Feedback on the items was also provided by mathematics leaders in the school. The examination was administered face-to-face at school under examination conditions. The duration of the examination was two hours.

Data Analysis

For the MA data, for each respondent, the score related to the level of MA selected by the respondent was assigned to each of the nine items. These scores were added to obtain a total MA score, which ranged from 9–45. For the mathematics achievement data, each student was assigned a score out of 100.

Before analysing the data per the research questions, we performed tests to check that the data satisfied the normality, linearity, and homoscedasticity assumptions to determine whether parametric or non-parametric tests were appropriate. The linearity and homoscedasticity assumptions were met; however, the normality assumption was not. Therefore, non-parametric tests were used where applicable.

Research Question 1 examined the distribution of MA among the sample. The first step in the analysis was to assign each respondent to one of three groups. This assignment was based on their total MA scores as follows: low anxiety (9–20), moderate anxiety (21–32), and high anxiety (33–45). This approach follows previous research (e.g. Mitchell & George, 2022; Carey et al., 2016). A bar graph was created to present the distribution of MA scores. For further analysis, we calculated the means and standard deviations for each item.

An analysis of variance (ANOVA) was used to ascertain whether there was a statistically significant difference in the mathematics achievement scores of students who reported low, moderate, or high levels of MA. For the third research question, Spearman's Rank-order Correlation analysis was performed to explore the relationship between MA and mathematics achievement among the sample. This non-parametric test was employed because the mathematics achievement data were not normal. We created a cross-tabulation with the three categories of MA used for Research Questions 1 and 2 related to low and high mathematics achievement to examine what profiles of MA and mathematics achievement emerged from the sample data. A student was placed within the low achievement group if they scored less than 60% on the end-of-term examination, which is the pass mark at the research site.

Results

Research Question 1: What is the distribution of MA (low, moderate, and high) among the Form 4 students?

Figure 1 presents the distribution of MA scores across three levels for the sample. The graph showed that moderate and high levels of MA were reported by the most (59%, *n* = 41) and least (16%, *n* = 11) number of students, respectively. The modal category (moderate anxiety) had more than twice the number of students than the category of low anxiety and more than three times that of the high anxiety band.

Beyond the aggregate results, the mean and standard deviation for the individual items (see Table 1) were analysed to ascertain the key contributors to the different MA levels. Based on the 5-point Likert scale: 1–Low anxiety, 2–Some anxiety, 3–Moderate anxiety, 4–Quite a bit of anxiety and 5–High anxiety, the higher the mean, the higher the level of MA a respondent reported experiencing.

Figure 1

Distribution of Students' MA Scores

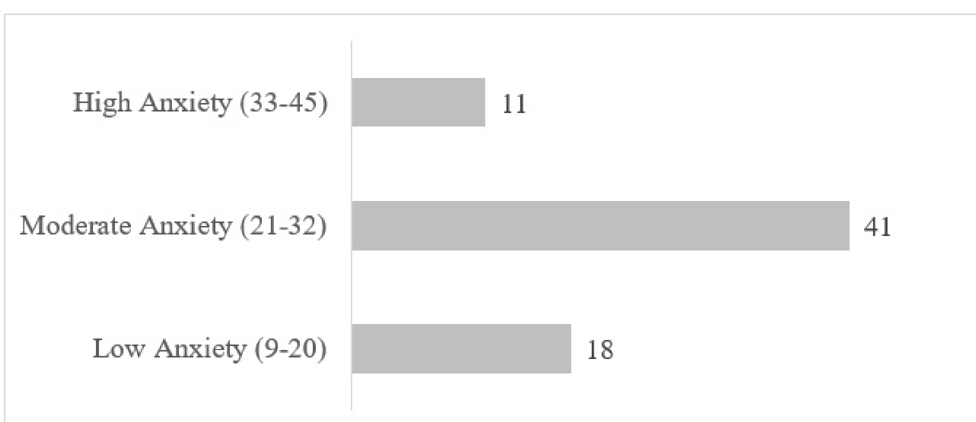


Table 1

Mean and Standard Deviation for the mAMAS Items

Item No.	Item	M	SD
1	Having to complete a worksheet by yourself	2.44	1.270
2	Thinking about a test the day before you take it	3.50	1.327
3	Watching the teacher work out a math problem on the board	1.71	1.105
4	Taking a math test	3.86	1.219
5	Being given math homework with lots of difficult questions that you have to hand in the next day	3.14	1.447
6	Listening to the teacher talk for a long time in math class	1.77	1.182
7	Listening to another child in your class explain a math problem	2.01	1.324
8	Finding out you are going to have a surprise math quiz when you start your math lesson	4.09	1.349
9	Starting a new topic in math	2.37	1.299

Table 1 shows that items related to taking a mathematics test (Items 2, 4, 8) had the highest mean values. The item "Working on difficult mathematics problems" (Item 5) also had a mean above three, similar to Items 2, 4, and 8. However, it was lower than these items (3.14) associated with these test-related situations and when engaged with challenging mathematics content. Item 3 (watching the teacher work out a math problem on the board) and Item 6 (listening to the teacher talk for a long time in math class) registered the lowest means and the only items with a lower mean of less than 2, which suggests that students experienced little to no MA during these learning-related situations. The standard deviation of all of the items was greater than 1.00, suggesting a substantial dispersion of the scores around the mean and variability in responses.

Research Question 2: Is there a statistically significant difference in the mathematics achievement of Form 4 students who report low, moderate, and high levels of MA?

A one-way between-groups analysis of variance (ANOVA) examined students' mathematics achievement based on their levels of MA. The results showed that there was no statistically significant difference among the three groups: $F(1.339) = 2$, $p = 0.269$. The mean score differences between groups were minimal. The effect size, measured by eta squared, was 0.038, suggesting that 3.8% of the variance in students' mathematics achievement could be attributed to their MA levels.

Research Question 3: What is the relationship between Form 4 secondary students' MA and their mathematics achievement?

The Spearman Rank Order Correlation test revealed a small, non-significant, negative relationship between MA and mathematics achievement ($r_S(68) = -.21$, $p = .089$).

Research Question 4: What profiles of MA and mathematics emerge from the sample data?

Table 2 shows the distribution of MA and mathematics achievement levels for the sample. Interestingly, no clear pattern of MA and mathematics achievement emerged from the data. For each MA level, there were varying levels of performance. For example, there were instances where students with high MA levels achieved high scores in mathematics, challenging the notion that high MA correlates with low achievement. There were an equal number of high and low-achieving students for students who self-reported low MA. Overall, this data highlights the complexity of the relationship between MA and mathematics achievement among Form 4 students. This individual-level data is likely to prove helpful to guidance counsellors and teachers as they seek to plan targeted interventions for different students.

Table 2

Distribution of MA and Mathematics Achievement Levels

MA	Mathematics Achievement		Total
	Low	High	
Low	9	9	18
Moderate	12	29	41
High	4	7	11
Total	25	45	70

Discussion

This research investigated the prevalence of MA in a sample of students from the TCI at the upper-secondary level; whether there was a statistically significant difference in the mathematics achievement of students who report low, moderate, and high levels of MA; and the correlation between MA and their mathematics achievement. It found that 16% of the respondents reported high MA, and most students reported a moderate level of MA. The latter finding aligns with our hypotheses, as well as with Demedts et al. (2022) and research involving Jamaican high school students who also responded to the mAMAS scale (George & Dowdie, 2021). In keeping with Cipora et al. (2022), who note that there is no consensus related to the prevalence of MA because different self-report measures are used in investigating MA, our result differs substantially from Zakaria et al. (2012) and Khatoon and Mahmood (2010) who also conducted research among secondary school students in developing countries. Almost one-third of their sample reported high MA, and there did not appear to be a modal MA category.

Ramirez et al. (2018) posit that differences in how individuals interpret their mathematics achievement and experiences inside and outside of school may account for the variability in MA that they report, and the results related to MA and mathematics achievement. Ramirez et al.'s interpretation explanation is based on "existing appraisal theory…which argues that emotional outcomes and attitudes are based on the interpretation of events, physiological cues, personal behaviour, and internal states" (p. 151). It may also explain the seemingly conflicting results of this research and others, that some students excel in mathematics despite experiencing high levels of MA (Devine et al., 2018; Lee, 2009), while many low-achieving students report low levels of MA. We argue that these results are not contradictory, but instead highlight the nuances of how MA manifests among individuals within the same school and sometimes even within the same classes taught by the same mathematics teacher.

Form 4 in the TCI and the Caribbean are in the first year of preparation for high-stakes tests taken at the end of high school in Form 5. Previous literature has suggested that high levels of MA at the upper secondary level may be attributable to an increase in the difficulty of mathematics that students encounter (Termizi & Mahmud, 2022). Considering the result that most of the MA students reported were linked to testing situations, perhaps the anticipation of the high-stakes test and its implications for future work and studies could be a factor for students with high MA. This hypothesis would need to be empirically investigated.

The result that moderate MA was reported by most of the students also coincides with the notion that psychological constructs are generally normally distributed, which means that the largest number of respondents would be located in the centre of the distribution (Mann, 2020). Figure 1 shows that although the MA distribution was slightly skewed, moderate MA was the modal MA band.

In relation to the second research question, this research found no statistically significant difference in mathematics achievement among the low, moderate, and high MA groups. Most previous studies have reported contrasting findings (Roos et al., 2015; Yavuz, 2018; Zakaria et al., 2012). Furthermore, the present research, in keeping with most previous studies (e.g. Barroso et al., 2021; Zhang et al., 2019), found a negative correlation between MA and mathematics achievement (rho = -.205, n=70, p = 0.089). However, the relationship was not significant. These results underscore Cipora et al.'s (2022) assertion that the relationship between MA and mathematics achievement varies across samples and the need for research from diverse contexts. The small, non-significant, negative relationship between MA and mathematics achievement found in this research was not able to support or refute any of the theoretical frameworks linking MA and mathematics achievement.

Conclusion

This study investigated the distribution of MA, the relationship between MA and mathematics achievement, and the individual MA–mathematics achievement profiles of a sample of Form 4 students from the TCI. A key result of this research concluded that moderate MA was the modal MA level. However, a substantial proportion of the sample (16%) reported that they experienced high MA, which is concerning. Furthermore, the results showed that there was no statistically significant difference in the mathematics achievement of Form 4 students who reported low, moderate, and high MA. Non-significant results were also obtained in relation to the relationship between MA and mathematics achievement. This result is noteworthy, since many studies report significant results relating to the MA-mathematics achievement relationship (Barroso et al., 2021). Consistent with most previous research, however, this study found that the relationship was negative. Another interesting and notable result of this research was that no clear pattern of MA and mathematics achievement emerged from the data. For each MA level, there were varying levels of performance. This result confirms Cipora et al.'s (2022) assertion that the connection between the variables of MA and mathematics achievement is both dynamic and nuanced, and provides empirical evidence of this. This is a noteworthy contribution to the empirical literature, considering that only a small number of studies have explored this dimension of the MA-mathematics achievement relationship.

The results of this research have implications for practice and future research. TCI, like many other countries, has raised concerns about students' achievement in mathematics. Exploring variables which may be associated with achievement is, therefore, imperative in addressing the issue. Internationally, MA has been found to be a key variable related to students' mathematics achievement. However, for the TCI sample, it did not emerge as a significant variable. Therefore, within that research context, additional research is needed to investigate other factors which may have a more robust relationship with students' mathematics achievement. No clear pattern of MA and mathematics achievement relation emerged from this research. The majority of students who reported high MA (n = 7) were high achievers, and nine low-achieving students experienced low MA. Future research, perhaps of a qualitative nature, could be conducted to gain further insight into results like these where the specific contributory factors, socioenvironmental or otherwise related to MA, could be explored. This information would be valuable in developing interventions for students with high MA, whether they were low or high achieving students.

This research was undertaken in a small developing country where research related to MA had not been previously conducted. This quantitative research ended up being small-scale, which is a key limitation of the research. This was due to the low informed consent and assent responses, rendering the results non-generalisable to the research population. This low response rate is concerning and may be indicative of the low priority that empirical research may hold in that jurisdiction or the unfamiliarity with it. These speculations would need to be confirmed in future research. Another limitation is that only one data collection instrument was used in the research, which limited triangulation of results. As previously stated, future research could include qualitative data collection methods such as interviews or focus group discussions in research results. Notwithstanding the aforementioned, there is merit in conducting research using diverse samples and jurisdictions to establish a comprehensive, inclusive, and current portrait of MA (Dowker et al., 2016; Szczygieł & Pieronkiewicz, 2021). While the research community embraces the notion of inclusion, there is an onus on the under-researched to engage in and report high-quality research. This study has added such research to the existing studies on key elements related to MA, such as prevalence and its link to mathematics achievement. It has also expanded the small number of existing studies that have been conducted within the Caribbean and neighbouring territories.

Acknowledgements

We appreciate the parents and guardians who granted informed consent for their children's participation in this study, as well as the students who took part.

Christina Anderson-Waugh is a dedicated and accomplished mathematics educator with over 10 years of experience in teaching and mentoring students. Holding both a Bachelor's and a Master's degree in Mathematics Education from the University of the West Indies, she has consistently demonstrated a passion for making mathematics accessible and enjoyable for all learners.

Email: christina.anderson03@mymona.uwi.edu

Lois George, PhD, is a Senior Lecturer in Mathematics Education at The University of the West Indies, Mona. She holds advanced degrees in Mathematics Education and Measurement, Testing, and Evaluation. Her research focuses on innovative pedagogical strategies for enhancing mathematical cognition and addressing the affective domain in mathematics education.

Email: lois.george02@uwimona.edu.jm

References

Al Mutawah, M. A. (2015). The influence of mathematics anxiety in middle and high school students math achievement. *International Education Studies, 8*(11), 239–252. https://doi.org/10.5539/ies.v8n11p239

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181–185. https://doi.org/10.1111/1467–8721.00196

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology, 130*(2), 224-237. https://doi.org/10.1037//0096–3445.130.2.224

Ashcraft, M. H., Krause, J. A., & Hopko, D. R. (2007). Is math anxiety a mathematical learning disability? In D. B. Berch & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities* (pp. 329–348). Paul H. Brookes Publishing Inc.

Asikhia, O. A. (2014). Effect of cognitive restructuring on the reduction of mathematics anxiety among senior secondary school students in Ogun State, Nigeria. *International Journal of Education and Research, 2*(2), 1–20. https://www.ijern.com/journal/February-2014/30.pdf

Atwell-Chin Hong, F. (2021). *An exploratory study of mathematics anxiety in Caribbean preservice teachers,* Andrews University]. Michigan, US. https://digitalcommons.andrews.edu/cgi/viewcontent.cgi?article=3029&context=dissertations

Baddeley, A., Eysenck, M. W., & Anderson, M. C. (2014). *Memory* (2nd ed.). Routledge. https://doi.org/10.4324/9781315749860

Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin, 147*(2), 134–168. https://doi.org/10.1037/bul0000307

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences, 2*(1), 4–12. https://doi.org/10.1177/2372732215601438

Carey, E., Hill, F., Devine, A., & Szücs, D. (2016). The chicken or the egg? The direction of the relationship between mathematics anxiety and mathematics performance. *Frontiers in Psychology, 6*(1987), 1–6. https://doi.org/10.3389/fpsyg.2015.01987

Carey, E., Hill, F., Devine, A., & Szűcs, D. (2017). The modified abbreviated math anxiety scale: A valid and reliable instrument for use with children. *Frontiers in Psychology, 8*(11), 1–13. https://doi.org/10.3389/fpsyg.2017.00011

Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J. M., Szűcs, D., & Mammarella, I. C. (2022). Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychology Review, 34*(1), 363–399. https://doi.org/10.1007/s10648–021–09618–5

Cipora, K., Santos, F. H., Kucian, K., & Dowker, A. (2022). Mathematics anxiety–where are we and where shall we go? *Annals of the New York Academy of Sciences*, 1–11. https://doi.org/10.1111/nyas.14770

CSEC maths passes down but English pass rate up. (2019). *Turks and Caicos Weekly News.* https://tcweeklynews.com/csec-maths-passes-down-but-english-pass-rate-up-p9945–127.htm

Demedts, F., Reynvoet, B., Sasanguie, D., & Depaepe, F. (2022). Unraveling the role of math anxiety in students' math performance. *Frontiers in Psychology*, *6379*, 1-9. https://doi.org/10.3389/fpsyg.2022.979113

Devine, A., Hill, F., Carey, E., & Szűcs, D. (2018). Cognitive and emotional math problems largely dissociate: Prevalence of developmental dyscalculia and mathematics anxiety. *Journal of Educational Psychology, 110*(3), 431–444. https://doi.org/10.1037/edu0000222

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology, 7*(508), 1–16. https://doi.org/10.3389/fpsyg.2016.00508

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link. *Current Directions in Psychological Science, 26*(1), 52–58. https://doi.org/10.1177/0963721416672463

George, L., & Dowdie, D. (2021). Investigating the prevalence of mathematics anxiety and its relationship to gender in high school students in Jamaica. *Journal of Education and Development in the Caribbean*, *19*(2), 48-74. https://doi.org/10.46425/j219026323

Gopal, K., Salim, N., & Ayub, A. (2020). Study on mathematics self-efficacy and anxiety among Malaysian upper secondary students using fuzzy conjoint analysis. *Malaysian Journal of Mathematical Sciences, 14*, 63–79. https://einspem.upm.edu.my/journal/fullpaper/vol14sdec/5.%20Kathiresan.pdf

Griffith, S. A. (2015). *School-based assessment in a Caribbean public examination*. The University of the West Indies Press. https://doi.org/10.37234/AMBZWUPE

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, 33–46. https://doi.org/10.2307/749455

Jaggernauth, S., & Jameson-Charles, M. (2015). Primary teacher mathematics anxiety, teacher efficacy and mathematics avoidance. In M. Carmo (Ed.), *Education applications and developments Advances in education and educational trends* (pp. 44–58). InScience Press.

Justicia-Galiano, M. J., Martín-Puga, M. E., Linares, R., & Pelegrina, S. (2017). Math anxiety and math performance in children: The mediating roles of working memory and math self-concept. *British Journal of Educational Psychology, 87*(4), 573–589. https://doi.org/10.1111/bjep.12165

Khatoon, T., & Mahmood, S. (2010). Mathematics anxiety among secondary school students in India and its relationship to achievement in mathematics. *European Journal of Social Sciences, 16*(1), 75–86.

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*(3), 355–365. https://doi.org/10.1016/j.lindif.2008.10.009

Luu-Thi, H.-T., Ngo-Thi, T.-T., Nguyen-Thi, M.-T., Thao-Ly, T., Nguyen-Duong, B.-T., & Tran-Chi, V.-L. (2021). An investigation of mathematics anxiety and academic coping strategies among high school students in Vietnam: A cross-sectional study. *Frontiers in Education, 6*, 1–14. https://doi.org/10.3389/feduc.2021.742130

Maas, B., Pakeman, R. J., Godet, L., Smith, L., Devictor, V., & Primack, R. (2021). Women and Global South strikingly underrepresented among top-publishing ecologists. *Conservation Letters, 14*(4), 1–9. https://doi.org/10.1111/conl.12797

Mahajan, S. L., Ojwang, L., & Ahmadia, G. N. (2023). The good, the bad, and the ugly: Reflections on co-designing science for impact between the Global South and Global North. *ICES Journal of Marine Science, 80*(2), 390–393. https://doi.org/10.1093/icesjms/fsac115

Malcolm, D. (2023). Transformative math opportunity for TCI; Singapore style is coming. *Magnetic Media*. https://magneticmediatv.com/2023/01/transformative-math-opportunity-for-tci-singapore-style-is-coming/

Maloney, E. A. (2016). Math anxiety: Causes, consequences, and remediation. In K. R. Wentzel & D. B. Miele (Eds.), *Handbook of motivation at school* (2nd ed., pp. 408–423). Routledge. https://doi.org/10.4324/9781315773384

Mann, P. S. (2020). *Introductory statistics* (10th ed.). John Wiley & Sons.

Ministry of Education, Youth, Sports & Library Services [Turks and Caicos Islands]. (2018). *Turks and Caicos Islands government education sector plan 2018–2022*. http://online.fliphtml5.com/kfvop/siis/#p=1

Mitchell, L., & George, L. (2022). Exploring mathematics anxiety among primary school students: Prevalence, mathematics performance and gender. *International Electronic Journal of Mathematics Education*, *17*(3), 1-11. https://doi.org/10.29333/iejme/12073

Moyo, C. (2023). Secondary school students' mathematics anxiety: A Zimbabwean perspective. *Texila International Journal of Academic Research*, *10*(2). https://doi.org/10.21522/TIJAR.2014.10.02.Art006

Nakamura, G., Soares, B. E., Pillar, V. D., Diniz-Filho, J. A. F., & Duarte, L. (2023). Three pathways to better recognise the expertise of Global South researchers. *npj Biodiversity, 2*(1), 1–4. https://doi.org/10.1038/s44185–023–00021–7

Namkung, J. M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research, 89*(3), 459–496. https://doi.org/10.3102/0034654319843494

OECD. (2013). *PISA 2012 Results: Ready to learn (Volume III): Students' engagement, drive and self-beliefs*. PISA, OECD Publishing. https://doi.org/10.1787/9789264201170-en

Presmeg, N. (2007). The role of culture in teaching and learning mathematics. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 435–458). NCTM.

Radević, L., & Milovanović, I. (2023). Current trends in math anxiety research: A bibliometric approach. *International Journal of Science and Mathematics Education*, 1–18. https://doi.org/10.1007/s10763–023–10424–4

Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist, 53*(3), 145–164. https://doi.org/10.1080/00461520.2018.1447384

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551–554. https://doi.org/10.1037/h0033456

Richland, L. E., Naslund-Hadley, E., Alonzo, H., Lyons, E., & Vollman, E. (2020). Teacher and students' mathematics anxiety and achievement in a low-income national context. *Mind, Brain, and Education, 14*(4), 400–414. https://doi.org/https://doi.org/10.1111/mbe.12253

Roos, A.-L., Bieg, M., Götz, T., Frenzel, A. C., Taxer, J., & Zeidner, M. (2015). Experiencing more mathematics anxiety than expected? Contrasting trait and state anxiety in high achieving students. *High Ability Studies, 26*(2), 245–258. https://doi.org/10.1080/13598139.2015.1095078

Rubinsten, O., Marciano, H., Eidlin Levy, H., & Daches Cohen, L. (2018). A framework for studying the heterogeneity of risk factors in math anxiety. *Frontiers in Behavioral Neuroscience, 12*(291), 1–11. https://doi.org/10.3389/fnbeh.2018.00291

Statistics Authority Turks and Caicos Islands. (2017). *Education Statistics 2013–2016*. Government of the Turks and Caicos Islands. https://www.gov.tc/stats/statistics/social/6-education

Szczygieł, M., & Pieronkiewicz, B. (2021). Exploring the nature of math anxiety in young children: Intensity, prevalence, reasons. *Mathematical Thinking and Learning*, 1–19. https://doi.org/10.1080/10986065.2021.1882363

Taylor, V. (2023). Despite global teacher shortage, TCI schools to be fully staffed for new school year. *Newsline TCI*. https://www.newslinetci.com/post/despite-global-teacher-shortage-tci-schools-to-be-fully-staffed-for-new-school-year

Termizi, A. K. A., & Mahmud, M. S. (2022). Mathematics anxiety and relationship with mathematics achievement of form four students. *International Journal of Academic Research in Business and Social Sciences, 12*(11), 2894–2901. https://doi.org/10.6007/IJARBSS/v12-i11/15336

Yáñez-Marquina, L., & Villardón-Gallego, L. (2017). Math anxiety, a hierarchical construct: Development and validation of the Scale for Assessing Math Anxiety in secondary education. *Ansiedad y Estrés, 23*(2–3), 59–65. https://doi.org/10.1016/j.anyes.2017.10.001

Yavuz, G. (2018). Mathematics anxiety of ninth grade students. *Journal of Education and Training Studies, 6*(5), 21–27. https://doi.org/10.11114/jets.v6i5.3044

Zakaria, E., Zain, N. M., Ahmad, N. A., & Erlina, A. (2012). Mathematics anxiety and achievement among secondary school students. *American Journal of Applied Sciences, 9*(11), 1761–1765. https://doi.org/10.3844/ajassp.2012.1828.1832

Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology, 10*(1613), 1–17. https://doi.org/10.3389/fpsyg.2019.01613

Appendix 1

Mathematics Anxiety Questionnaire

This questionnaire is designed to find out about Form 4 students' math anxiety. You are kindly requested to answer all the questions honestly. The information you give will be treated with confidentiality and only used for compiling relevant research reports. This is not a test, and hence there is no wrong or right answer.

Section A

Name: ____

Sex: Male [ ] Female [ ] Other [ ]

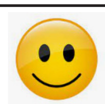
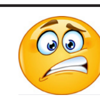
Age: ______________

Class: _____________________

Section B

Please give each sentence a score in terms of how anxious you would feel during each situation. Carefully read each sentence and, using the scale at the top, select the number that **best** describes how you feel.

Modified Abbreviated Math Anxiety Scale

						
		Low anxiety	**Some anxiety**	**Moderate anxiety**	**Quite a bit of anxiety**	**High anxiety**
1	*Having to complete a worksheet by yourself*	1	2	3	4	5
2	Thinking about a test the day before you take it	1	2	3	4	5
3	Watching the teacher work out a math problem on the board	1	2	3	4	5
4	Taking a math test	1	2	3	4	5
5	Being given math homework with lots of difficult questions that you have to hand in the next day	1	2	3	4	5
6	Listening to the teacher talk for a long time in math class	1	2	3	4	5
7	Listening to another child in your class explain a math problem	1	2	3	4	5
8	Finding out you are going to have a surprise math quiz when you start your math lesson	1	2	3	4	5
9	Starting a new topic in math	1	2	3	4	5