UNIVERSITY OF CAPE COAST

MULTILEVEL ANALYSIS OF FACTORS ACCOUNTING FOR MATHEMATICS ACHIEVEMENT OF STUDENTS IN TIMSS 2011: A COMPARISON OF GHANA AND SINGAPORE

RICHMOND PANYIN

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BY

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Thesis submitted to the Department of Education and Psychology of the College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for award of Doctor of Philosophy degree in Measurement and Evaluation

JULY 2022

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ………………………………… Date: ………………

Name:

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature ……………………… Date: ……………..

Name:

Co-Supervisor's Signature……………………………… Date: ……………..

Name:

ABSTRACT

The study sought to investigate the impact of student- and classroom/school-level factors on eighth-grade math achievement in Ghanaian and Singaporean students. Three research questions guided the study. A comparative research design was adopted. The data was obtained from 7323 students nested within 161 schools in Ghana and 5251 students nested within 129 schools in Singapore who participated in the 2011 Trends in International Mathematics and Science Study (TIMSS). A school questionnaire, teacher questionnaire, student questionnaire, and the TIMSS math achievement test were used to collect data. Hierarchical Linear Modelling was used to analyse the data. The study showed that 40.71% and 43.49% of the total variance in math achievement were accounted for by school-level differences in Ghana and Singapore, respectively. Meanwhile, the results showed that student-level differences contributed to 59.29% and 56.51% of the total achievement of Ghanaian and Singaporean students, respectively. The results also showed that in both countries, the math achievement of eighth grade students was largely influenced by student-level characteristics. At the student level, the results showed that students' like for learning math and confidence in doing math were the strongest contributors to the math achievement of the Ghanaian and Singaporean students, respectively. At the school level, school discipline and safety, as well as school emphasis on academic success, were the most influential factors on Ghanaian and Singaporean students' mathematics achievement, respectively. This study recommends that the Ministry of Education and Ghana Education Service critically look at students' characteristics, which can be developed both at the classroom and school levels, for improvement in their mathematics achievement.

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DEDICATION

To my wife, Faustina and children, Favour, Blessing, Kazia and Jerestorer for their encouragement and patience during my studies.

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CHAPTER ONE

INTRODUCTION

The importance of student accomplishment in mathematics instruction cannot be over emphasised. For instance, the Organisation for Economic Co-operation and Development (OECD) study indicated that the achievement of all 15-year-olds in Ghana in mathematics and science could boost Ghana's Gross Domestic Product (GDP) by up to 3,881 per cent (Armah, 2016). Despite the relevance, mathematics remains a problem for students. Literature reveals that students do not perform well at all levels of education (i.e., basic, secondary, and higher). Participation of Ghana in the Trends in International Mathematics and Science (TIMSS) 2003, 2007 and 2011 likewise indicated low performance in mathematics. Evidence from TIMSS results indicate that Ghana ranked 45th out of 46 countries in 2003, ranked 58th out of 59 countries in 2007 and ranked 63rd out of 63 countries in 2011. In contrast, Singapore, which virtually acquired independence in the same year as Ghana, rated 1st, 3rd, and 2nd in TIMSS 2003, 2007 and 2011 respectively. These results show the strengths and flaws of the education structures in these nations. This study intends to compare these two education systems by studying the 2011 TIMSS dataset of both nations to discover areas where Ghana's education system could be improved.

Background to the Study

The value of mathematical achievement among students cannot be overstressed. This is due to the important function it plays in achieving success in several aspects of life. Numerous domains of human endeavour rely on mathematics for success. If citizens of a nation lacked adequate and high-quality mathematical abilities, for instance, there would be little major national progress. Students' achievement in mathematics is frequently viewed as crucial to the future development of a nation, and this is true for mathematics, science, modern technology, and engineering (STEM) programmes (Baker & LeTendre, 2005; Sekler & Wobmann, 2003). Therefore, training and preparing students to be successful in math has been the paramount objective of schooling in many nations (Mullis, Martin, Foy & Arora, 2012).

Because of the relevance of student performance in mathematics, researchers, policymakers, and mathematics educators continue to search for effective ways to assess student performance and improve student performance in math. Every discipline is critical to the advancement of society, but mathematics and science remain central factors underpinning almost every discipline in this regard (Opoku-Agyemang, 2019).

Moreover, the role of mathematics in solving the nation's problems cannot be relegated to the background. The study of mathematics is expected to achieve the following goals, among others: critical thinking, logical reasoning, problem-solving skills of learners and the development of creative thinking methods for successful solution design. The state is aware of these goals and this is essentially what the mathematics curricula at all levels of education emphasis. As described above, mathematics education should achieve the following: to advance the critical thinking and problem-solving capacities of individual learners, which translates into the nation's ability to effectively address and find solutions to local, national, and international problems. Any nation that fails in the mathematical education of its citizens has indirectly failed in the nation's problem-solving capacity. It takes critical minds to tackle the critical problems facing a nation. Similarly, the academic progress of students at various levels of education in a country might not be achieved without mathematics education. In Ghana, for example, the transition from Senior High School (SHS) to higher education might not be possible without acceptable performance in mathematics.

Despite its importance, mathematics remains a problem for students. Evidence from the literature shows that students do not perform well. For example, the results of West African Secondary School Certificate Examination (WASSCE) candidates in Ghana from 2007 to 2019 show that the trends observed in mathematics performance were quite low, except for a few years of high performance (Abreh, Owusu & Amedahe, 2018; WASSCE, 2017, 2018, 2019). For example, WASSCE Mathematics (Core) 2019 recorded the most significant improvement in A1 to C6 compared to 2018 (38.33% to 65.31%). Available Basic Education Certificate Examination (BECE) results show that the pass rate in mathematics was not constant between 2009 and 2013, but on average 62.26% of BECE candidates passed.

The results of the National Education Assessment (NEA) study between 2005 and 2013 show that in both Primary 3 (P3) and Primary 6 (P6), about 40% of students did not even reach the minimum competency of 35% in mathematics. About 18% of P3 and P6 achieved well in mathematics. In the 2016 NEA, the Primary 4 (P4) class was used instead of the P3 for the study. The result shows that less than 25% of the students in P4 and P6 were proficient in mathematics. Similarly, according to the report of the Chief Examiner of the Institute of Education (UCC), Mathematics was the lowermost performing subject in the first Semester College of Education examination in 2013/2014 academic year (Enu, Agyman, & Ekum, 2015).

Building a comprehensive image of achievement in mathematics across the numerous and diverse countries of Sub-Saharan Africa (SSA) is problematic because the available data is very fragmented. Unfortunately, much of the available information points in the same general direction—towards low average levels of mathematics achievement and competence (Bethell, 2016). Available results emanating from international studies (e.g., TIMSS) on the mathematics performance of SSA students (Ghana, South Africa, and Botswana) are consistently far below the international average and are at the bottom of international rankings (Bethell, 2016). According to Beatty and Pritchett (cited in Bethell, 2016), a large body of evidence shows that mathematics education in SSA is in a precarious state. The learning gap between countries in the region and international norms is so large that it may never be reduced, let alone closed, without comprehensive and sustained interventions at all stages of education.

Countries participate in large-scale international comparative achievement studies (LINCAS) in mathematics and science to make sure that each of their students has the same instructive and academic possibilities comparable to those in other nations (Butakor, 2015). LINCAS are defined as studies that evaluate the influence of contextual elements at the school, classroom, and student, levels on performance. Comparative studies aim to "use the world as an educational laboratory to inform policymakers at all levels about alternatives in educational organisation and practice" (Robitaille & Garden, 1989, p. 5). TIMSS, administered by the International Association for the Evaluation of Educational Achievement (IEA), and PISA, administered by OECD, are two large-scale international examinations that measure science and mathematics. The IEA's achievement studies have two main, general objectives (Plomp, 1998): (a) to inform policymakers and educators about the efficiency of their school system in comparison to other effective school systems; understanding what is going on in other systems is the first step to learning from them; and (b) to assist in determining why there are disparities between education systems. The drive of TIMSS was "to allow researchers to apply theories about contextual factors that contribute to achievement simultaneously to systems of diverse contexts" and "to isolate the factors directly relating to student learning that can be manipulated through policy change in, for example, curricular emphasis, allocation of resource, or instructional practices" (Martin & Kelly, 1996, p.3).

The participation of Ghana in TIMSS was to gauge the development of usable attitudes, math skills, and values that eight grade students will need to become successful in their selected careers and the development of the nation as well. (Anamuah-Mensah, Asabere-Ameyaw, & Mereku, as cited by Butakor, 2015). Since TIMSS started in 1995, it has reported every four years on the science and math performance of eighth- and fourth-grade students in education systems and participating nations. The TIMSS 2011 assessment is the fifth in a series (Mullis, Martin, Ruddock, O'Sullivan, & Prenschoff, 2009). TIMSS 2015 and 2019 are, respectively, the sixth and seventh assessments in the series. First, TIMSS was chosen for this study because Ghana has never participated in any other international large-scale comparative assessment. Second, it is the largest international database devoted completely to mathematics and science that provides data on mathematics achievement.

TIMSS is one of the most well-known, highly regarded, and thorough comparative education studies examining students' science and mathematics achievement in accordance with the school curriculum in many countries (Ceylan & Akerson, 2014: Ker, 2016). More than 63 and slightly more than 58 nations participated in TIMSS in 2015 and 2019, respectively (Mullis, Martin Foy, Kelly, & Fishbein, 2020). The emphasis on mathematics and science enables future research to conduct a more in-depth examination of specific courses and curricula within science and mathematics. The key objective of these research investigations is to give parents, educators, educational policymakers, researchers, and other education-interested bodies with information about similarities and differences between education systems. This information can be used by education system stakeholders to obtain insight into the upsides and downsides of their respective educational systems (Bos, 2002). According to Harmouch, Khraibani, and Atrissi (2017), one of the aims of TIMSS is to make available international benchmarks and high-quality data that can aid policymakers and researchers in identifying the upsides and downsides of their school/education systems in comparison to those of other education systems.

A survey of the relevant literature reveals that TIMSS findings have been utilised in various ways in various nations. In Singapore and the Czech Republic, for instance, the pace of curriculum revisions has sped up; Scotland is undergoing tremendous transformations in terms of classroom organisation, teacher training, and school goal setting; in Romania and Spain, new topics and content have been added to the mathematics and science curricula; in Australia, national benchmarks have been established in literacy and numeracy; and in the Korea Republic, curriculum reform and teachers' professional development are underway (Geary, Hamson & Hoard, 2000). This analysis demonstrates the significance and function of TIMSS findings in educational policy for enhancing the quality of mathematics and science achievement in schools (Bos, 2002).

In 2003, Ghana participated TIMSS assessment in the eighth grade and continued in 2007 and 2011. According to Anamuah-Mensah et al. (2004), the goal of participation was to analyse grade 8 (JHS 2 in Ghana) students' accomplishment in math and science using a worldwide standard. Results from Ghanaian eighth grade mathematics assessments across the years of participation in TIMSS 2003, 2007 and 2011 indicate abysmally low performance and achievement. Ghana could not participate in the subsequent TIMSS editions (i.e., 2015 and 2019) since previous funding from World Bank was no longer available (Armah, 2016). Since 2003, TIMSS studies have demonstrated that Ghanaian student progress in math and science lagged far below that of students from many East Asian nations, including Japan, Korea, Chinese Taipei, and Singapore (Mullis, Martin, Gonzalez, & Chrostowski, 2004; Mullis, Martin, Foy, & Arora, 2012). In this study, Singapore was chosen as a comparative country because it is one of the highest-performing nations in East Asia.

Despite similarities in some of the educational background indicators between Ghana and Singapore such as; common educational systems (centralized education), schooling age, multilingual society, achievement of independence about the same year, language of instruction and language of the test, results from Singaporean eight grade students who also participated in TIMSS 2003, 2007 2011, 2015 and 2019, show consistent top-level performance and achievement in mathematics. In 2003, Ghana came in 45th position out of 46 countries, in 2007 it ranked 58th out of 59 countries, and in 2011 it ranked 63rd out of 63 nations. In contrast, Singapore ranked first among 46 nations in TIMSS 2003, third among 59 nations in TIMSS 2007, second among 63 nations in TIMSS 2011, first among 39 nations in TIMSS 2015, and first among 58 nations in TIMSS 2019. The average mathematics scale score of 276 obtained by Ghanaian students in TIMSS 2003 was below the international average score of 476. Evidence from TIMSS also indicates that, Ghanaian eight-graders' average mathematics scores of 309 in TIMSS 2007 and 331 in TIMSS 2011 were statistically significantly below the global average score of 500 (Butakor, 2015). Singapore, on the other hand, scored an average scale score of 605, which is 129 scale points above the international average scale score of 476 in TIMSS 2003. Singapore eight-grader students' scale mean mathematics scores of 593 in TIMSS 2007 and 611 in TIMSS 2011 were above the international average scale score of 500. Furthermore, the average mathematics scale scores of 621 in TIMSS 2015 and 616 in TIMSS 2019 were also above the international average score of 500 (Mullis et al., 2020).

The TIMSS results for the two nations demonstrate that Singapore's educational system is resilient and consistent in its support of students' high-level mathematics proficiency. TIMSS 2015 data indicate that Japan, Singapore, Chinese Taipei, Hong Kong SAR, and Korea, continue to outperform all other participating nations in math at the fourth and eighth grades, retaining twenty years advantage. Unfortunately, as a low-performing nation in the TIMSS, Ghana has not empirically examined the Singaporean education system in order to discover the secrets to a successful school system that encourages high-level mathematics and science accomplishments. In expanding theories regarding mathematics teaching, learning, and accomplishment, worldwide comparative study in math education has the potential to improve theory and practise, as well as our educational systems. By comparing Ghana's mathematical achievement with that of a higher-achieving nation such as Singapore in TIMSS, it is hoped that the factors responsible for the Ghanaian education system's low performance will become evident.

Since the first cycle of TIMSS in 1995, investigators from various participating nations have undertaken secondary data analyses of its data in order to: (a) comprehend and model the variables that impact math performance; (b) determine how eighth-grade students' math performance is shared between and within schools; and (c) identify problem areas in educational systems that could be improved (Papanastasiou, 2000; Martin et al., 2020; Lamb & Fullarton, 2002; Chepete, 2008; Wang, 2008; Azine & Halimah, 2012; Mohammedpour, 2012; Pangeni, 2014; Skouras, 2014; Butakor, 2015).

Nevertheless, few researches have investigated the association between students' mathematical achievement and individual-, classroom-, and school-level characteristics, particularly among Ghanaian eighth-graders (JHS2). In addition to the reports authorised by the Ministry of Education, two studies employing TIMSS data were done in 2010 and 2015. Frempong (2010) analysed the TIMSS 2003 data using the Hierarchical Linear Model (HLM) statistical approach. According to the findings of Frempong's study, there was a considerable disparity in the mathematical achievement of children across schools. Furthermore, the study discovered that the most proficient mathematics students were males with highly educated parents, great academic aspirations, and a passion for math, confidence in their ability to master mathematics, and who attended schools in cities as opposed to villages. Butakor (2015) also used the HLM statistical procedure to investigate the TIMSS 2007 and 2011 concurrently. The two studies reviewed above did not report which of the three levels of factors (i.e., student-, classroom-, and school) largely influences mathematics education in Ghana. It is not known whether student-level factors or school/class-level factors significantly drive mathematics education at the eight-grade level in Ghana. This remains an open question and the current study seeks to find an answer to it. Moreover, Butakor (2015) demonstrated that teaching experience was unrelated to mathematical achievement in both TIMSS 2007 and TIMSS 2011 years, contrary to the conclusions of earlier research (Greenwald, Hedges, & Laine, 1996; Kaya & Rice, 2010; Fetler, 2001). The current study tries to analyse these inconsistent outcomes and gaps. This study seeks to advance earlier research by contrasting Ghana's low-achieving education system with a Singaporean high-achieving education system with the primary goal of learning from Singaporean education system. Since one of the fundamental goals of TIMSS is to provide high-quality data that can aid policymakers and researchers in identifying the benefits and drawbacks of their school systems in comparison to other education systems through secondary data analysis (Harmouch, et al., 2017).

There are several variables that either directly or indirectly affect how well students do in school (Ghagar et al., 2011). Therefore, the factors in this current study were selected mainly based on the conceptual model of this study; theoretical framework, research evidence in terms of factors that contribute significantly to mathematics achievement; contradictory findings on some factors; factors that can be easily implemented in Ghana's education system; factors that have a direct relationship with students' learning that can be manipulated through policy change, factors that policymakers can manage and improve within the Ghanaian contest; and the findings of MOE's mandatory analysis of TIMSS data.

Statement of the Problem

Even though Ghana and Singapore gained total independence in about the same years (i.e., 1957 and 1965), the two countries were also labelled third world countries after independence. The two countries have common educational systems such as centralized education, schooling age, medium of instruction, multilingual society and the language of the TIMSS test. The results from Singaporean eight-grade students who participated in TIMSS 2003, 2007, 2011, 2015, and 2019 showed consistent top-level performance and achievement in mathematics as compared with their counterparts (Mullis et al., 2020; Mullis et al., 2012). For instance, Singapore was ranked 1st, 3rd, and 2nd in TIMSS in 2003, 2007, and 2011 respectively. Furthermore, Singapore ranked 1st out of 63 countries in TIMSS 2015 and ranked 1st out of 58 countries in TIMSS 2019. Ghana, on the other hand, ranked 2nd from the bottom in TIMSS 2003 and 2007, and ranked 63rd out of 63 participating countries in 2011. The mean mathematics scale score of 276 that Ghanaian students earned on the TIMSS 2003 test was lesser than the international mean of 476 (Mullis et al., 2004; Mullis et al., 2012). TIMSS data also suggests that Ghanaian eighth-graders' mean mathematics scores of 309 in TIMSS 2007 and 331 in TIMSS 2011 were significantly lower than international mean score of 500 (Butakor, 2015; Mullis et al., 2012; Anamuah-Mensah, Mereku & Ghartey-Ampiah, 2008; Mullis et al., 2004). Singapore, on the other hand, received a mean scale score of 605, which is 129 scale points higher than the mean scale score of 476 for the entire world. In both TIMSS 2007 and TIMSS 2011, the scaled average mathematics results of Singapore eighth-graders were above the international average scale score of 500. In addition, the average mathematics scale scores of 621 in TIMSS 2015 and 616 in TIMSS 2019 were both above the international average of 500 (Mullis et al., 2020; Mullis, Martin, & Tom, 2016, Mullis et al., 2012, Mullis et al., 2004).

As seen above, however, there is a large variance in the mean math performance of students in the two nations. The excellent and consistent high accomplishment of East Asian education systems, especially Singapore, in the TIMSS has attracted unprecedented attention from educational experts and policymakers worldwide (Mohammedpour & Abdul-Ghafar, 2014; Leung, 2001; Zhu & Leung, 2011; Mohammedpour, 2012; Harmouch et al., 2017; Ker, 2016; Ceylan & Server, 2020). According to Ker (2016), Singaporean students' outstanding success in mathematics and science has attracted a significant deal of international interest and spurred various debates about the country's educational ethos, processes, and structures.

The achievement gap in mathematics between these high-achievers has remained for several years (Fleischman, Hopstock, Pelczar, & Shelley, 2010; Chung, Lee, & Kim, 2014). This finding is an indication of more robust and consistent Asian education systems that have a record of enhancing students' overall mathematics achievement. Thus, a better system to learn from. Today, Singapore's education system has been described as "world-leading" and has won international recommendations, including one by the British Education Minister, Michael Gove (Baker, 2010).

Unfortunately, Ghana, as a low-achieving country in TIMSS, has not been drawn to this high-achieving Singaporean school system in order to empirically find out the keys to a successful school system that promotes high-level mathematics and science achievements. In the TIMSS 2007 Ghana report, it was indicated that little was done in the report to explain the huge variation between the performance of students in high-achieving countries and those of Ghana. According to the report, faculty, graduate students, and educators are required to conduct additional in-depth analyses of the extremely rich TIMSS database in order to provide policymakers with a better comprehension of the complex interaction between such factors and the most promising paths to effective instruction and learning. It is important for humanity to be able to learn from each other's accomplishments and failings, and education is no exception. That is the essence of this current study.

The literature review in terms of TIMSS comparative studies in eighth grade mathematics achievement between Ghana and Singapore (reference point) is highly limited. Most of the studies reviewed compared Singapore's education system with European and Asian countries, leaving out almost all

African countries that participated in TIMSS (e.g., Fan & Zhu, 2007; Ker, 2013; Gao, 2014; Ker, 2016; Ker, 2017; Mathew & Balachandran, 2018; Guven & Akcay, 2019; Ceylan & Server, 2020). One study included the two countries (Ghana and Singapore) in a comparative study involving over 48 participating nations in TIMSS 2007 (Mohammedpour, & Abdul-Ghafar, 2014). Multilevel investigation revealed that of the total difference in math performance, 39.99%, 20.61%, 40.39%, were accounted for by country-, school-, and student-level variation, respectively. These findings might differ when considering specific countries like Ghana and Singapore. At the student level, confidence in doing math, followed by social economic status, were significant contributors to achievement (Mohammedpour & Abdul-Ghafar, 2014). Since the countries were too many, the study did not capture which of the two levels (school/classroom, and student) largely contributed to math achievement in specific countries or education systems. Filling this gap in literature might lead to policy direction which seeks to understand which level of schooling process significantly drives mathematics achievement at the eighth grade. In the same vein, the study did not highlight which variable or factor was the strongest predictor at the various levels in specific countries. In fact, few countries were mentioned in the discussion of the results.

The most enlightening feature of the TIMSS study is the conclusion that the highest performer, Singapore, had significant levels of illiteracy and a poor quality of education in the 1960s, possibly worse than Ghana. Indeed, when Singapore gained independence in 1965, it was an impoverished, small (700 km^2) tropical island with scant fresh water, few natural resources, rapid population growth, housing challenges, and periodic strife between its religious and ethnic bodies (Lee, 2000). During this time, there was no compulsory schooling and fewer high school graduates, college graduates, and skilled employees than in Ghana (Armah, 2016; Lee, 2000). Today, Singapore is a dazzling hub for international commerce, banking, and transportation. Its turnaround in one generation "from third world to first" is one of Asia's greatest success stories. Hence, the interest in making comparison between Ghana and Singapore grade eight students in terms of their math achievement using TIMSS 2011 data with the view of learning from the Singaporean effective education system that enables high mathematics achievement.

Purpose of the Study

The main intent of this thesis was to make a comparison of Ghana and Singapore eighth grade students in terms of their mathematics achievements using TIMSS 2011 data with the view of learning from the Singaporean effective education system which facilitates high mathematics achievement. Therefore, the specific objectives of the current study are to:

1. Determine which of the two levels (student, classroom/school) has the most impact on mathematics achievement in the two countries.
2. Determine which of the selected student-level factors best contributes to mathematics achievement in the two countries.
3. Determine which of the selected classroom/school-level factors best contribute to the mathematics achievement in the two countries.

Research Questions

Three research questions guided the study:

1. Which of the two levels (student, classroom/school) has the most impact on the mathematics achievement of eighth grade Ghanaian and Singaporean students?
2. What is the contribution of selected student-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students?
3. What is the contribution of selected classroom/school-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students?

The Significance of the Study

First, the findings of the study are expected to reveal which student-classroom and school/classroom level factors significantly predict mathematics in the top-achieving country (Singapore) and how the low-achieving country like Ghana can strengthen or improve these characteristics that significantly predict mathematics achievement. The investigation has uncovered evidence that could prompt the MOE and Ghana Education Service (GES) examination into educational systems that support students' high mathematical achievement.

The MOE and GES may use the findings of this study to improve mathematics teaching and learning in Ghana. This may provide the MOE and GES, teachers, and principals of basic schools with information that may assist them in developing methods to improve the mathematical achievement of Junior High School (JHS) students.

The MOE and GES may use the findings of this study to improve mathematics instruction and learning in Ghana. The study has made a substantial contribution to the existing literature on TIMSS findings in Ghana. It is hoped that the results and conclusions of this study would lead to improvements in the way mathematics is taught in schools, thereby improving students' mathematical performance.

The study has highlighted what might be the possible factors accounting for the mathematics achievement difference between Ghanaian and Singaporean students. As a result, light has been shed on the factors that contributed to low Ghanaian student achievement in mathematics in 2011 and how to improve the situation. Therefore, it has provided practitioners and policymakers (Ferrini-Mundy & Schmidt, 2005) with important suggestions for enhancing math instruction and learning in these and other global school systems.

Delimitations

There are so many factors that influence educational achievement differences, particularly in mathematics achievement. These factors may include construct bias, item bias, and many more. This study was limited to some selected factors at levels one and two as being influenced by the conceptual framework. There may be other factors that are important in predicting student success, but these factors were not considered in this study.

In TIMSS 2011, more than 62 countries participated, but this current study was limited to one of the top-scoring participating countries (Singapore) and one of the low-scoring participating countries (Ghana). The study also focused only on eighth graders from the two selected counties in TIMSS

2011. Lastly, the investigation was limited to only the math attainment of the grade eight students of the two nations in TIMSS 2011.

Limitations

Because of its quantitative nature, this study has several limitations.

Firstly, the study's findings are derived on the students' self-reported responses to the questionnaires. As the survey instrument did not provide a universal definition, students from diverse national and cultural backgrounds understood items according to their own knowledge. Buckley (2009) argued that students from nations with a low gross domestic product (GDP), with a poorer socioeconomic background, or with less schooling may produce more socially desirable responses. Self-reported data collection is one of the limitations of the TIMSS study.

Secondly, the research was restricted to only two multilevel analyses, with the second level combining school and classroom level variables. In this analysis, the merging of the classroom and school levels into a single level may have led to mistakes in the estimation of parameters and variances explained by the various variables. This constraint was as a result of the two-stage stratified sampling employed in the TIMSS study; an initial selection of schools was followed by a probability random selection of intact classes from those schools. This means that multilevel analysis of TIMSS data is limited to two levels, unless students were randomly selected from many intact classes.

Thirdly, the study is restricted to mathematics items used to measure mathematical achievement in the 2011 TIMSS. I had no influence over the development, administration, or rating of these items.

Finally, the highly technological nature of the Singaporean educational system, as compared with Ghana, might also have an influence on the comparative nature of this current study. This could bias the estimation of population parameters favouring Singaporean students. Since the usage of technology influences the mathematical achievement of students. Despite these limitations, the results of this investigation reveal the impact of student, classroom, and school factors on math achievement.

Definition of Terms

Mathematics achievement: is the total of each student's 2011 TIMSS mathematics test score.

Grade Eight Students: They comprised the grade with the highest proportion of students aged 13 during the testing period. In Singapore, these are in Form 2 of Secondary School whilst in Ghana; they are students in Form 2 of Junior High School.

Organization of the Study

This investigation has been organized into five chapters. Chapter One highlights the background of the study; the problem statement; the study's purpose; research questions; the significance of the study; delimitation, limitations, and finally the organization of the study. Chapter Two of the report focuses on the literature related to the investigation. The literature covers both empirical and theoretical reviews. The third chapter presents the procedures or methodology employed for the investigation. It examines the research design, the population, sampling procedure for the study, instruments, procedures data collection, missing data analysis, data processing and analysis. Chapter Four highlights the research results and discusses the findings in relation to the reviewed literature. The fifth chapter focuses on summary, applicable conclusions, recommendations based on the findings of the research, and proposals for further research.

CHAPTER TWO

LITERATURE REVIEW

The main intent of the study was to make a comparison between Ghana and Singapore eight grade students in terms of their mathematics achievement using TIMSS 2011 with the view of learning from the Singaporean education system, which facilitates high mathematics achievement. The study specifically focused on which of the two levels (student and classroom/school) of the school system significantly drives the learning of mathematics in the two countries. The study also examined which of the selected classroom/school-level contextual factors and student-level factors measured in the TIMSS 2011 were the best or strongest predictors of math achievement of eight grade students in the two countries.

This chapter gives a brief review of TIMSS project, TIMSS assessment framework, Ghanaian and Singaporean education systems, and mathematics curriculums. It also reviewed literature related to school effective theoretical models with a specific focus on the model that was used for the current study. Finally, literature about variables that are evidenced from research studies that significantly predict mathematics achieved was examined.

TIMSS Project

The IEA, is the main sponsor of the TIMSS project. Since 1959, the IEA, has conducted cross-national achievement surveys. In the 1960s, the IEA was the first organisation to conduct an international comparison of educational outcomes, accomplishment to acquire a greater knowledge of the consequences of policy across countries' various educational systems (Mullis & Martin, 2017). The focus of the IEA is to offer high-quality data on student success results and educational environments. Central "to IEA's vision is the notion that the diversity of educational philosophies, models, and approaches that characterize the world's educational systems constitute a natural laboratory in which each country can learn from the experiences of the others" (Mullis et al., 2009, p. 2).

International comparative studies provide empirically grounded insights into what matters in education in diverse contexts by comparing the outcomes and characteristics of these experiments. For this reason, the results of these investigations are documented and made easily accessible to everyone with an interest. The IEA was founded in 1959 with the mission of undertaking comparative research on educational practices and policy across the globe (Mullis & Martin, 2017). Its members have since increased to more than 60 nations. In TIMSS 2019, 64 countries and eight benchmarking systems at the fourth and eighth grade levels participated (Mullis & Martin, 2017). In 1964 and 1970–71, the IEA conducted the First International Mathematics Study (FIMS) and the First International Science Study (FISS). In 1980-1982 and 1983-1984, respectively, the Second International Mathematics Study (SIMS) and the Second International Science Study (SISS) were performed. Since then, the IEA has undertaken four-year cycles of assessments of science and math performance at the same time. In 1994-1995, students at defined levels of pre-tertiary education participated in the Third International Mathematics and Science Study (TIMSS), a combined mathematics and science examination.

In 1999, TIMSS-Repeat or TIMSS-R, research founded on a similar procedural foundation and identical to TIMSS 1995, was done. The purpose of the TIMSS-R was to re-evaluate the achievement of eighth grade students in math and science in order to determine any pattern in the performance of students since 1995 (Butakor, 2015). TIMSS was renamed Trends in International Mathematics and Science Study in 2003, 2007 and 2011(Butakor, 2015). Every four years, TIMSS has published a report on the academic performance of fourth and eighth graders in nations across the globe since 1995. Nations that have taken part in subsequent series of TIMSS (1995, 1999, 2003, 2007, 2011, 2015, and 2019) have unmatched access to data on the advancement or deterioration of their students' achievement in math.

Assessment Frameworks of TIMSS 2011

Assessment frameworks give a structured conceptual map of a programme of study's learning outcomes. Where curricular frameworks specify what is to be taught, assessment frameworks detail what is to be assessed as proof of learning according to needed standards (Mullis et al., 2009). Assessment ideas (and their definitions) and theoretical assumptions that allow others to relate to and hypothetically adapt the framework to different fields of assessment are incorporated into an assessment framework. In addition, an assessment framework describes the operationalization of an evaluation. It blends theory and practise and describes both what and how (Mullis et al., 2009).

The TIMSS 2011 Assessment Frameworks serve as a blueprint for IEA's eighth grade mathematics assessment work (Mullis et al., 2009). The TIMSS 2011 Assessment Frameworks comprise three frameworks and describe the assessment design that served as the foundation for TIMSS 2011 implementation (Mullis et al., 2009). They include; the TIMSS 2011 Mathematics Framework, the TIMSS 2011 Science Framework and TIMSS 2011 Contextual Framework (Mullis et al., 2009). Because this thesis uses the results of eighth grade mathematics data for the analysis, the TIMSS 2011 science frame work will not be considered in this review.

TIMSS 2011 curriculum model

TIMSS examines how educational opportunities are provided to students and the factors that determine how students use these possibilities (Mullis et al., 2009). “TIMSS curriculum model involves three components: the intended curriculum, the implemented curriculum, and the attained curriculum” (Mullis et al., 2009, p.10). Figure 1 depicts the curricular modal for the TIMSS.

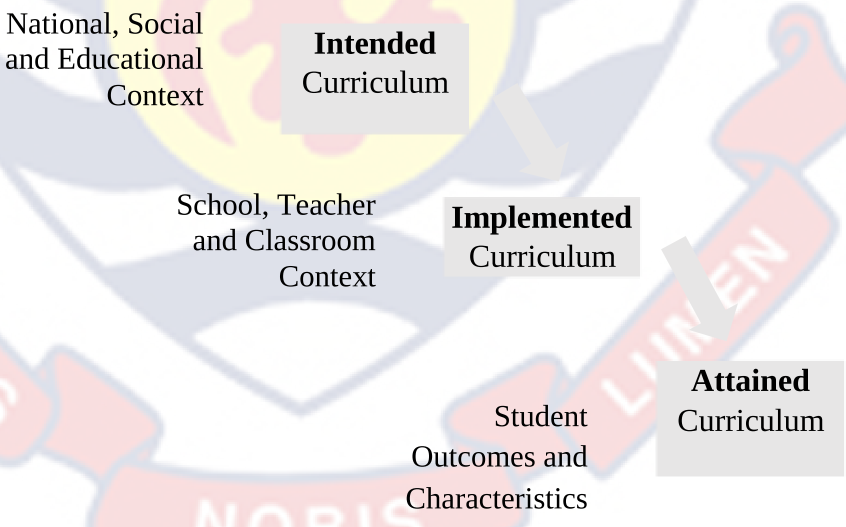

Figure 1: TIMSS Curriculum Model Source**:** (Mullis et al., 2009)

TIMSS uses the model in figure 1 to describe how students in participating countries are learning math. The TIMSS Encyclopaedia and questionnaires, along with the mathematics achievement tests, give detailed information about how students are learning (Mullis et al., 2009). TIMSS requests that countries contribute data on the math and science levels that students are expected to achieve through the TIMSS Encyclopaedia and curriculum surveys (Mullis et al., 2009). TIMSS assesses students at the end of four years of school and the end of eight years in school to aid in decision making and the implementation of school policy (Mullis et al., 2009). Because TIMSS looks at the relationship between curriculum and instruction and student achievement, it's critical that TIMSS assesses math and science achievement at the same level of schooling across nations. To put it another way, for fair comparisons, students should have studied math and science for the same number of years in formal schooling (Mullis et al., 2009).

TIMSS 2011 mathematics assessment framework

The TIMSS 2011 math assessment framework is set up along two dimensions: a content dimension that lists the domains or subject areas to be tested (like data and chance, geometry, algebra and number, at the eighth grade), and a cognitive dimension that lists the domains or thinking processes to be tested (that is, reasoning, applying, and knowing) (Mullis et al., 2009). The cognitive domains show how students should act when they are working with math information. Tables 1 and 2 show how much of the testing time is set aside for each area and cognitive domain in the TIMSS 2011 eighth-grade test (Mullis et al., 2009).

Table 1: Percentages of the TIMSS 2011 Mathematics Assessment Devoted to Content Domain at Eighth Grade

Content Domain	Percentages
Number	30%
Algebra	30%
Geometry	20%
Data and Chance	20%

Source: Mullis et al. (2009)

The content areas list the exact math topics that will be tested on the TIMSS 2011 eighth grade test. Each content domain is made up of different topic areas. Each topic area has a list of goals that are covered in the math curricula of many member countries (Mullis et al., 2009). These grade-specific goals are written in terms of the understanding or skills that aligned items are meant to bring out in students. In many circumstances, the development in learning across grades is determined by the level of difficulty of the materials employed (Mullis et al., 2009).

The number content domain encompasses number comprehension, number representation, number relationships, and number systems. Students should have developed number sense and computational fluency by eighth grade, understand the meanings of operations and their interrelationships, and be able to solve problems using numbers and operations. Knowledge and abilities in the number subject area include: (a) whole numbers; (b) fractions and decimals; (c) integers; and (d) ratio, proportion, and percentages. In computation, the emphasis is on fractions (Mullis et al., 2009; Mullis & Martin, 2017). Recognizing and extending patterns, utilising algebraic symbols to depict mathematical situations, and growing proficiency in forming equivalent expressions and solving linear equations comprise the algebra content domain. Functions, algebraic expressions, patterns, and equations are the three main algebraic topic areas (Butakor, 2015). Mullis et al. (2009) state that by the eighth grade, students should be able to analyse the qualities and characteristics of various two- and three-dimensional geometric figures, such as the lengths of their sides and the sizes of their angles, and provide interpretations based on geometric relationships (Mullis et al., 2009). They should be able to use the Pythagorean Theorem to solve problems. It is important to emphasize the use of geometric properties and their interactions.

In addition to comprehending geometric properties and relationships, students must be competent in geometrical measurement, including the accurate use of measuring tools, estimation where necessary, and the selection and application of formulas for perimeters, areas, and volumes (Mullis et al., 2009). The geometry topic area includes understanding of coordinate representations and spatial visualisation abilities in addition to grasping coordinate representations and utilizing spatial visualisation skills to navigate between two- and three-dimensional objects and their representations (Mullis et al., 2009). Students should be able to use symmetry and translation to analyse mathematical issues. Geometry is divided into three topics: (a) geometric shapes, (b) geometric measurement, and (c) position and motion (Mullis et al., 2009). The data and chance content category covers the ability to organise data obtained by others or by oneself and to show data in charts and graphs that are beneficial for answering queries that require the data collecting. This subject area encompasses a comprehension of data misinterpretation difficulties. The content domain of chance and data comprises the following three key subject areas: (a) Chance (b) Data interpretation (c) Data organisation and display (Mullis et al., 2009; Mullis & Martin, 2017).

Table 2: Percentages of the TIMSS 2011 Mathematics Assessment Devoted to Cognitive Domain at Eighth Grade

Cognitive domain	Percentages
Knowing	35%
Applying	40%
Reasoning	25%

Source: TIMSS (2011)

According to Mullis et al. (2009), for students to successfully answer TIMSS test questions, they must not only be conversant with the mathematics subject being tested, but also utilise a variety of cognitive skills. According to Mullis et al. (2009), developing these skills is critical when developing an assessment such as TIMSS 2011, since it guarantees that the test covers the required range of cognitive skills across the content domains indicated above.

The first domain, knowing, includes the knowledge, ideas, and procedures that students must understand. Math and familiarity with math concepts are required for the ability to use math or reason about maths problems (Mullis et al., 2009). The more relevant information a student can recall and the more concepts he or she comprehends, the greater the likelihood that he or she will be able to solve a variety of problems and learn more about mathematics (Mullis et al., 2009; Mullis & Martin, 2017).

The second area, applying, emphasises students' capacity to use their conceptual understanding and knowledge to solve problems. The applied domain requires the use of mathematical techniques in a variety of circumstances. Students must build representations using their knowledge of mathematical facts, talents, and procedures, as well as their grasp of mathematical ideas (Mullis et al., 2009; Mullis & Martin, 2017).

The third domain, reasoning, encompasses multistep problems, complicated contexts, and new situations besides the solution of ordinary issues (Mullis et al., 2009). Mathematical reasoning requires the aptitude for logical, and organised thought (Mullis et al., 2009; Mullis & Martin, 2017).

TIMSS 2011 contextual framework

Because learning takes place in context rather than in vacuum, TIMSS makes every effort to collect data on the critical components that enable improved math teaching and learning (Mullis et al., 2009). Contextual factors influence student learning in a variety of ways. Family learning assistance, student attitudes, and the type of school, school resources, instructional methodologies, and teacher traits for example, all have a significant impact on student achievement (Mullis et al., 2009). To fully comprehend what the TIMSS accomplishment results indicate and how they might be used to support student learning in math and science, it is vital to first comprehend the settings in which learning occurs (Mullis et al., 2009).

Teachers differ in terms of their education and training, teaching experience, dispositions, and usage of certain instructional methods. Furthermore, student behaviours, attitudes, and preparedness in the classroom might influence instructional decisions and student learning (Mullis et al., 2009). Even though school regulations and resources frequently establish the tone for the classroom and provide a framework for learning, Mullis et al. (2009) discovered that students' everyday classroom activities have a greater likelihood of having a direct effect on their math skills. According to Mullis et al. (2009), the teaching methods and resources used, such as curricular subjects addressed, teaching strategies and the access to devices such as computers and laboratory equipment, are crucial for developing teaching and learning patterns in the classroom.

Students bring experiences and expectations with them that influence their drive and learning capacity. Students' prior knowledge and attitudes toward learning math influence the success of instructors and schools in curriculum implementation. Students come to school with a diverse set of experiences and backgrounds.

Student accomplishment in science and mathematics is strongly linked to student attributes (for example, spoken language and gender) and family background variables, according to a large body of research (e.g., socioeconomic background, immigration status). The discrepancy between boys and girls in mathematics is moderate and smaller than the achievement gap related with disparities in family context, according to some studies (Coley, 2001; McGraw, Lubienski, & Strutchens, 2006). Consistently, research demonstrates a substantial positive correlation between achievement and socioeconomic level indicators, such as the occupational class of parents or carers (Bradley & Corwyn, 2002; Willms, 2006; Campbell, Haveman Wildhagen & Wolfe, 2008).

In addition to availability of an Internet connection and computer, number of books in the home, and the existence of a study desk, several home background components have been proven to be significant predictors of math proficiency (Woessmann, 2003). These characteristics also reflect the domestic learning atmosphere and might have an impact on students' overall educational goals, including math competence (Mullis et al., 2009). It has been discovered that social resources have a good effect on student accomplishment, however the usefulness of parental support for schooling remains unclear (Marks, Cresswell, & Ainley, 2006; Lee & Bowen, 2006).

The motivation of students to learn can be influenced by their liking of the subject, their sense of its worth, and their opinion of its relevance to their future and current career (Butakor, 2015). According to Mullis et al. (2009), a learner's personal interest in a subject encourages him or her to move beyond surface-level information in the learning process. In addition, a student's confidence in mastering the subject can influence their motivation. TIMSS statistics indicate that students with greater self-esteem or self-efficacy do better in math on average. According to Mullis et al. (2009), encourage students to interact with the curriculum, a positive orientation toward math and science, as well as a strong sense of self-motivation, and display perseverance, focus, and effort.

It is stimulating to know that the diligence that sustains the time spent in doing homework in specific subject like mathematics is influenced by the interest of the student in the said subject. This interest is mostly or to a great extent engendered by the attitudes of the students towards the subject. According to research (Mullis et al., 2009; Mullis & Martin, 2017; Trautwein, Luedtke, Kastens, & Koeller, 2006), the amount of effort put into homework and the results might be greater predictor of academic accomplishment than the amount of time spent on it. Since these contextual variables were found to influence and significantly predict mathematics achievement, they were captured in TIMSS 2011 contextual framework to access their contribution to mathematics achievement. This thesis selected a few of these variables based on the conceptual framework to investigate their contribution to eighth grade mathematics achievement.

Assessment design of TIMSS 2011

The TIMSS 2011 international examination of eighth-grade student performance includes written mathematics exams as well as questionnaire sets that collect information on social and educational contexts of achievement in math (Mullis et al., 2009). Monitoring developments in student achievement from one assessment cycle to another is a crucial part of TIMSS's mission, as is measuring math performance in a way that reflects how math is taught in participating countries (Mullis et al., 2009).

TIMSS 2011 student booklet design

Because of TIMSS's high reporting aims, the examination contains far more items than any single student can answer throughout the testing period (Mullis et al., 2009). As a result, TIMSS 2011 employs a matrix-sampling technique in which the whole assessment collection of science and mathematics items at each grade level is packaged into 14 student achievement booklets, with each student completing only one booklet. Each question is provided in two booklets, allowing students' responses from different booklets to be linked (Mullis et al., 2009). Participating classrooms distribute booklets so that groups of students working on each booklet have virtually identical levels of competency (Mullis et al., 2009).

The distribution of items across content and cognitive domains inside each block is as near to that of the full item pool as possible (Mullis et al., 2009). TIMSS 2011, like TIMSS 2007, is divided into 28 blocks, 14 of which contain mathematics questions and 14 of which have science questions. Student booklets were made using various combinations of these item blocks (Mullis et al., 2009). Eight of the fourteen mathematics blocks and eight of the fourteen scientific blocks were received in 2011 for use in trend measurement. The remaining 12 blocks (6 mathematics and 6 science) have been released into the public domain for use in publishing, research, and education, and will be replaced by newly generated TIMSS 2011 items. As a result, the 28 blocks in the TIMSS 2011 assessment are made up of 16 blocks of trend items (8 mathematics and 8 science) and 12 blocks of freshly produced items for 2011 (Butakor, 2015).

Mathematics achievement of Singaporean and Ghanaian students in TIMSS 2003, 2007, 2011, 2015 and 2019

TIMSS rankings

Ghana's consistent abysmal performance in TIMSS across the years of participation that is, 2003, 2007, and 2011 is a great concern to mathematics education in Ghana. The overall performance in these years was abysmally low. This is evidenced from TIMSS ranking position of Ghana. Ghana ranked 45^{th} out of 46 countries in 2003, ranked 58^{th} out of 59 countries in 2007 and ranked 63^{rd} out of 63 countries in 2011. In contrast, Singapore ranked 1^{st} out of 46 countries in TIMSS 2003, ranked 3^{rd} out of 59 countries in TIMSS 2007, ranked 2^{nd} out of 63 countries in TIMSS 2011, ranked 1^{st} out of 39 countries in TIMSS 2015 and ranked 1st out of 58 countries in TIMSS 2019 (Mullis et al., 2004, 2012, 2016, 2020).

Average mathematics scale score

The average mathematics scale score of 276 obtained by Ghanaian students in TIMSS 2003 was below the international average score of 476. Evidence from TIMSS also indicates that, Ghanaian eight-graders average mathematics score of 309 in TIMSS 2007 and 331 in TIMSS 2011 were statistically significantly below the global average score of 500 (Butakor, 2015). As indicated earlier, Ghana could not participate in TIMSS 2015 and 2019 due to financial constraint.

Singapore on the other hand scored average scale score of 605 which is 129 scale points above international average scale score of 476. Singapore eight grader students scale mean mathematics score of 593 in TIMSS 2007, 611in TIMSS 2011, 621 in TIMSS 2015 and 616 in TIMSS 2019 were above the international average scale score of 500 (Mullis et al., 2004, 2012, 2016, 2020).

International benchmarks achievement

The TIMSS mathematics achievement scale summarises student performance on test items meant to assess a broad spectrum of student knowledge and skill. TIMSS defined four points on the scale for use as international benchmarks in order to provide relevant descriptions of what performance on the scale could signify in terms of the mathematics students know and can do. The TIMSS 2003 Advanced Benchmark is 625, the High Benchmark is 550, the Intermediate Benchmark is 475, and the Low Benchmark is 400. These benchmarks were selected to represent the range of ability demonstrated by students internationally. Ghanaian students' average TIMSS 2003 mathematics achievement scale score of 276 is much lower than the worldwide benchmark of 400. Findings from TIMSS 2003 also showed that only 2% and 9% of the Students in Ghana attained Intermediate and Low International Standards or Benchmark, respectively. This means that more than 75% of the Ghanaian students obtained an average grade below the Low International Benchmark. Ghana had no students reaching high and advanced benchmarks, respectively. This implies that almost all the Ghanaian eighth graders who participated in TIMSS have some basic knowledge of mathematics. Singapore, on the other hand, had an average mathematics scale score of 605, which is 20 scale points below the advanced international benchmark of 625. Results from TIMSS also indicate that 44% and 77% of Singaporean eighth-grader students who participated in TIMSS 2003 reached advanced and high international benchmarks, respectively. These findings imply that nearly half of the Singaporean students reached the International Advanced Benchmark, which is very impressive as compared with Ghanaian students. Performances at these benchmarks indicate that most Singaporean eighth graders can organize information, generalize, solve non-routine problems, draw, and justify conclusions from data, and can apply their understanding and knowledge in a wide variety of relatively complex situations. Results from TIMSS show that 93% and 99% of Singaporean students performed at the intermediate and low international benchmarks, respectively (Mullis et al., 2004, 2012, 2016, 2020).

Findings from TIMSS 2007 indicate that only 4% and 17% of the students from Ghana got to the Intermediate and Low International Benchmarks, respectively. This also means that more than 75% of the Ghanaian students obtained an average grade below the Low International Benchmark. Again, no Ghanaian students in TIMSS 2007 reached the high and advanced benchmarks, respectively. Performances at these international benchmarks suggest that almost all the Ghanaian eighth graders who participated in TIMSS have some knowledge of whole numbers and decimals, operations, and basic graphs. Singapore, in contrast, had an average mathematics scale score of 593, which is 32 scale points below the advanced international benchmark of 625.

Findings from TIMSS indicate that 41% and 74% of Singaporean eighth graders who participated in TIMSS 2007 reached Advanced and High International Benchmarks, respectively. These findings imply that nearly half of the Singaporean students reached the International Advanced Benchmark, which is remarkable as it is linked with Ghanaian students. Performances at these benchmarks indicate that most Singaporean eighth graders can apply their knowledge and understanding to solve problems and apply their understanding and knowledge in a variety of relatively complex situations. TIMSS findings reveal that 92% and 98% of Singaporean students performed at the intermediate and low international benchmarks, respectively. The above findings in terms of the performance across all four international benchmarks for Singaporean students are consistent with findings from TIMSS 2011. For instance, findings from TIMSS 2011 show that Singaporean students scored an average mathematics score of 611, which is 14 scale points below the advanced international benchmark of 625 (Mullis et al., 2004, 2012, 2016, 2020).

TIMSS results indicate that 48% and 78% of Singaporean eight-grader students who participated in TIMSS 2011 reached advanced and high international benchmarks, respectively. These findings imply that almost half of the Singaporean students again reached the International Advanced Benchmark, which is extremely outstanding as compared with Ghanaian students. Performance at these benchmarks reveals that most Singaporean students can apply their knowledge and understanding to solve problems and a variety of relatively complex situations. From the TIMSS findings, 92% and 99% of Singaporean students performed at the intermediate and low international benchmarks, respectively. Ghanaian students, on the other hand, recorded performance improvement at the various benchmarks. Evidence from TIMSS 2011 indicates that 46% and 75% of the students from Ghana acquired Intermediate and Low International Benchmarks, respectively, which is a marked improvement over the last two years of participation. This means that nearly a quarter of the Ghanaian students obtained an average grade below the Low International Benchmark. TIMSS findings reveal that 3% and 17% of Ghanaian students in TIMSS 2011 reached high and advanced benchmarks, respectively. The findings show improvement in the performance of Ghanaian students across all the four benchmarks, but they are still low in comparison with Singaporean students (Mullis et al., 2004, 2012).

Findings from TIMSS 2015 show that Singaporean students scored an average mathematics score of 621, which is 4 points lower than the advanced international benchmark of 625.

TIMSS results indicate that 54% and 81% of Singaporean eight-grader students who participated in TIMSS 2015 reached advanced and high international benchmarks, respectively. According to these findings, nearly half of Singaporean students again met the International Advanced Benchmark. Performance at these benchmarks reveals that most Singaporean students can apply their knowledge and understanding to solve problems in a variety of relatively complex situations and explain their reasoning. From the TIMSS findings, 94% and 99% of Singaporean students performed at the intermediate and low international benchmarks, respectively. Performance at these benchmarks reveals that most Singaporean students can apply their knowledge and understanding in a variety of relatively complex situations.

Findings from TIMSS 2019 show that Singaporean students scored an average mathematics score of 616, which is 9 points scale lower than the advanced international benchmark of 625. TIMSS results indicate that 51% and 79% of Singaporean eight-grader students who participated in TIMSS 2019 reached advanced and high international benchmarks, respectively. According to these findings, nearly half of Singaporean students again met the International Advanced benchmark. Performance at these benchmarks reveals that most Singaporean students can apply their knowledge and understanding to solve problems in a variety of relatively complex situations and explain their reasoning (Mullis et al., 2004, 2012, 2016, & 2020).

From the TIMSS findings, 92% and 98% of Singaporean students performed at the intermediate and low international benchmarks, respectively. Performance at these benchmarks reveals that most Singaporean students can apply their knowledge and understanding in a variety of relatively complex situations. These findings are consistent with previous findings of Singaporean students' benchmark performance. The results reveal consistency in the mathematics achievement of these students.

Achievement in content areas

In terms of mean performance in the math content areas adopted in the TIMSS assessment framework, Ghanaian students' mean performance in these five content areas was also below the international average. The international mean in TIMSS 2003 was placed at 467 for each of the five reporting domains. The mean performance of the Ghanaian eight-grade students in all the five mathematics content areas was as follows: Number, 289; Algebra, 288; Measurement, 262; Geometry, 278, and Data, 293. These mean scores were significantly lower than the international means in each of the content areas and were about 180 scale score points below the international mean. In contrast, Singaporean students' mean performance across all the five content areas is as follows: number, 618; algebra, 590; measurement, 611; geometry, 580; and data, 579. These mean scores were significantly higher than the international means in each of the content areas and were about 130 scale points above the international mean. The results indicate that Singaporean eight-grade students performed significantly above all five of the five mathematics content areas, whereas Ghanaian eight-grade students performed below all the reported mathematics content areas. Results from TIMSS 2007 indicate that Ghanaian students' achievement in all the reported content areas was also significantly below the international mean of 500 scale points. This is evidenced by the following content achievements:

Number, 310; Algebra, 358; Geometry, 278, and Data and Chance, 321 (Mullis et al., 2004, 2012, 2016, 2020).

In contrast, Singaporean students' mean performance across all the reported content areas was significantly above the international mean. This is shown in the following achievements: 597 is for numbers; 579 is for algebra; 578 is for geometry; and 574 is for data and chance. Findings from TIMSS 2011 in terms of mathematics content achievement for the two countries are consistent with earlier findings. For instance, Ghanaian students' performance across mathematics content areas was significantly below the international average score of 500 scale points. This is shown in the following results: number, 321; algebra, 358; geometry, 315; data and chance, 296. These mean scores were significantly lower than the international mean in each of the content areas and were about 142 scale score points below the international mean. On the other hand, Singaporean students' mean performance across all the reported content areas was significantly above the international mean of 500. This is shown in the following achievements: number, 611; algebra, 611; geometry, 612; and data and chance, 607 (Mullis et al., 2004, 2012).

Findings from TIMSS 2015 in terms of mathematics content achievement for Singapore are consistent with earlier findings. For instance, Singaporean students' mean performance for all the reported content areas was significantly above the international mean of 500. This is shown in the following achievements: Number is 629, Algebra is 623, Geometry is 617, and Data and Chance is 617 (Mullis et al., 2004, 2012, 2020). TIMSS 2019 yields comparable outcomes for Singapore in terms of math subject achievement. TIMSS 2015 found, for instance, that Singaporeans performed well in math subjects. For instance, the mean performance of Singaporean students across all reported curriculum areas was much higher than the global average of 500. This is demonstrated by the following accomplishment: Data and Chance is 620, Algebra is 611, Geometry is 619, and Number is 611. (Mullis et al., 2004, 2012, 2020).

Achievement in cognitive areas

In terms of average performance in the math cognitive areas adopted in the TIMSS assessment framework, Ghanaian students' average achievement in these three cognitive areas was also below the international average. The international mean in TIMSS 2003 was placed at 467 for each of the three reporting cognitive domains. The mean performance of the Ghanaian eight-grade students in all the three mathematics cognitive areas was as follows: knowing, 232; applying, 293; and reasoning, 313. These mean scores were significantly lower than the international means in each of the cognitive areas and were about 150 scale score points below the international mean. In contrast, Singaporean students' mean performance across all the reported cognitive areas was significantly above the international mean. This is shown in the following achievements: knowing, 591; applying, 611; and reasoning, 583. Results from TIMSS 2007 indicate that Ghanaian students' achievement in all the reported content areas was also significantly below the international mean of 500 scale points. This is evidenced by the following content achievements: knowing (313); applying (297); and reasoning (313). In contrast, Singaporean students' mean performance across all the reported content areas was significantly above the international mean. This is revealed in the following achievements: knowing, 581; applying, 593; and reasoning,

597. The TIMSS 2011 findings in terms of mathematics cognitive achievement for the two countries are consistent with previous findings (TIMSS 2003 and 2007). For instance, Ghanaian students' performance across mathematics cognitive areas was significantly below the international average score of 500 scale points. This is evidenced in the following results: knowing (331); applying (316); and reasoning (324). These mean scores were significantly lower than the international mean in each of the cognitive areas and were about 140 scale score points below the international mean. On the other hand, Singaporean students' mean performance across all the reported cognitive areas was significantly higher than the international average of 500. This is shown in the following achievements: knowing, 617; applying, 613; and reasoning, 604 (Mullis et al., 2004, 2012).

The results of the 2015 TIMSS in terms of mathematics cognitive achievement in Singapore are consistent with previous findings (TIMSS 2007 and 2011). For instance, Singaporean students' mean performance across all the reported cognitive areas was significantly higher than the international average of 500. This is shown in the following achievements: knowing, 633; applying, 619; and reasoning, 616 (Mullis et al., 2004, 2012, 2020).

The TIMSS 2019 findings for Singapore in terms of mathematics cognitive achievement are consistent with previous findings (TIMSS 2011 and 2019). For instance, Singaporean students' mean performance across all the reported cognitive areas was significantly higher than the international average of 500. This is shown in the following achievements: knowing, 614; applying, 614; and reasoning, 620 (Mullis et al., 2004, 2012, 2020). All these findings from TIMSS are indicators of the poor performance of Ghanaian students in mathematics across the years of participation (2003, 2007, and 2011). This wide mathematics achievement difference between Ghanaian and Singaporean students in TIMSS is a potential platform for investigation. That is what this study seeks to accomplish.

Some Assumptions of Cross-National Comparison

A basic assumption underlying most regional comparisons is that shared traits distinguish one region from another in educationally significant ways. Language, political structure, colonial past, economic system, national aspirations, and/or cultural roots may be the uniting features of any place. The authors of interregional comparisons encounter three difficulties. If they wish to demonstrate that two or more regions have comparable or distinct unifying characteristics, they must demonstrate the significance of these similarities and differences for learning. They must also demonstrate that the similarities and differences are significant learning tools.

Overview of Education Systems in Ghana

This study does a cross-national comparison between Ghana and Singapore. Therefore, it is preferable to comprehend the essential parallels and contrasts between these nations' educational systems during TIMSS 2011.

The TIMSS data utilized in this study were obtained within the framework of the previous educational system, making this review necessary. Despite the current educational reforms in Ghana, this study's conclusions are applicable to the new educational reforms. Education is essential to the growth of any nation, and is the most significant factor in national progress. In multiple ways, education is vital to national development. The greatest benefit of education is that it provides the country with the necessary labour force. A developed or educated society is one in which there is sufficient personnel and everyone holds his or her proper place to promote the growth of the state (Afolabi & Loto, 2012). Individuals with a high level of education are the most vital component of a highly developed society.

As a developing country, Ghana does everything it can to make sure that all Ghanaian children of school age can get a good, free education. Since Ghana became independent in 1957, this vision for education has led different political figures and authorities to make policy directives and make changes to education. The Free and Compulsory Universal Basic Education policy, which was set up in 1996 (FCUBE Policy Document, 1996), and the Education for All programme goals, which are based on the World Declaration on Education and focus on meeting students' basic learning needs, are two examples of policies and goals that are based on this idea (Butakor, 2015). As a result of the FCUBE initiative, the number of years spent in secondary school went from three to four in 2007. However, after the 2008 presidential elections, this number was cut to three (Butakor, 2015). In 2005, the implementation of a program to feed students, the provision of free school uniforms and computers, and the elimination of school fees in all public primary schools led to a significant increase in enrolment from prekindergarten to junior high school (Butakor, 2015). Ghana's education system has four stages: basic education, secondary education, tertiary education, and non-formal education (Butakor, 2015). According to the FCUBE policy, everyone is entitled to a free basic education. Here are the two levels that matter for TIMSS 2011: elementary school and high school. As part of the new education reform, the first level of basic education includes two years of preschool, two years of kindergarten, six years of primary school (1– 6), and three years of junior high school (1–3, or Grades 7–9). Children ages 4 and 5 go to kindergarten, and at age 6, they start first grade. In junior high school, which is the second-to-last stage of basic education, children know basic scientific, technical, and practical skills (Butakor, 2015). In Ghana, senior high school education is now part of what "basic education" means. So, in Ghana, basic education starts with kindergarten one (Kg) and ends with senior high school three (i.e., grade 12).

Even though previous and current governments have worked to enhance the standard of education in the nation, the education system still faces several challenges (Butakor, 2015). When the number of students at any level of education goes up, more classrooms, lecture halls, laboratories, and libraries need to be built. All grade levels need more qualified teachers, and teachers' professional development needs to be improved in all areas, especially math and science.

The Ministry of Education in Ghana oversees making rules about education. The ministry makes sure that policies are carried out in a way that meets educational goals and aims. In Ghana, the school system has been broken up into six levels: school, circuit, district, regional, national, and ministry. This was done to make it easier to manage and run pre-tertiary education. Circuits are clusters of schools within a same district that collaborate to enhance education. Circuit supervisors and assistant directors keep an eye on things from the outside (Butakor, 2015). Each of the 170 districts in Ghana has its own education office, which is run by a district director of education. Recently, the government of Ghana made more regions, bringing the total number of districts in the country to 260. Instead of ten, Ghana has sixteen regions. Inspectors in each region keep an eye on and check on secondary and postsecondary schools. At the national level, the National Council for Curriculum and Assessment (NACCA), which used to be called the Curriculum Research and Development Division of the Ghana Education Service, oversees doing research, given national tests, making a national curriculum, and writing textbooks. NACCA was responsible for the recent changes in education, which included making a new curriculum for elementary and high schools (Butakor, 2015). The Inspectorate Division of the Ghana Education Service works with the regions and districts to come up with rules for how to inspect senior high schools. In addition to full inspections, the inspectorate monitors schools, investigates complaints, and approves courses and programs in the country's pre-tertiary schools (Butakor, 2015). The Ghana Education Service, an agent of Ministry of Education, is responsible for implementing approved national pre-tertiary education policies and programs (Butakor, 2015). This is done to make sure that all Ghanaian children who are old enough to go to school get a fair and inclusive formal education, no matter their tribe, gender, disability, religion, or political beliefs. In order to do this, education is given more freedom at the metropolitan, municipal, and district levels (Butakor, 2015).

Language of instruction

Ghana's official language and the dominant language in government and business is English. It is also the standard instructional language. The community's original language is used as the instructional language throughout pre-school, kindergarten, and the first three years of elementary school (Grades 1-3), while English is taught as a subject (Butakor, 2015). There are approximately 77 spoken languages in the country, nine of which are officially recognised by the government: Dagbani, Ewe, Dangme, Gonja, Kasem, Dagaare-Wale, Ga, Akan (Fanti, Akuapem Twi, Ashanti Twi, Akyem, Nzema, and Kwahu). Starting in grade four, Ghanaian languages are taught in schools based on the native language of the area where the school is (Butakor, 2015).

Teacher education in Ghana during TIMSS 2011

This summary looks at how math and science teachers were trained during TIMSS 2011. In Ghana, all four levels of the school system are now covered by the teacher education system (Butakor, 2015). A certificate for nursery school teachers is given after a three-month course for pre-kindergarten teachers. Teachers who finish three-year programs at different colleges get Diplomas in Basic Education, which allow them to teach at the basic education level (Butakor, 2015). The University of Cape Coast oversaw the college of education's curriculum and evaluations.

Now, Ghana's 46 public and four private colleges of education are part of Ghana's state universities. The University of Education Winneba oversees the Komenda College of Education, for example. The Teacher Education Division of the GES oversees admitting and hiring future teachers and graduates. Butakor (2015) submits that the following are the minimum requirements for getting into three-year teacher education programs at teacher colleges with science and math as major subjects: Teachers-to-be must pass English, math, and either life skills or the Ghanaian language. They must also pass two electives in science, agriculture, or any technical subject. To improve how math, science, and technology are taught and learned in basic education schools and to make sure there are enough math and science teachers, the MoE has designated 15 colleges of education as science and math teacher education specialists (Butakor, 2015).

This intervention points out how important technology and science are to Ghana's growth. But in elementary school (Grades 1–6), general classroom teachers often teach all subjects, and they don't need to be experts in math or science (Butakor, 2015).

In some upper primary classrooms (Grades 4–6) and junior high schools (Grades 7–9), math and science must be taught by people who specialize in those subjects. Even though this law was passed, there are still not enough math and science teachers in Ghana (Butakor, 2015).

The new direction for teacher education in Ghana

Despite the various teacher education reforms in Ghana, as indicated earlier, the educational system is having trouble keeping up with the level of growth both nationally and internationally. Various challenges confront the educational system in Ghana. Hence, the government of Ghana launched a UK-sponsored transformation program, overseen by Cambridge Education, to improve Ghana's pre-service teacher training. It is worth noting that currently in Ghana, the colleges of education have been upgraded to degree-awarding institutions. This was based on research findings that the level of teachers' formal education contributes positively to the overall academic performance of students. Hence, the minimum formal education of teachers in Ghana should be a first degree in a specialised area (e.g., Junior High School Mathematics).

The mathematics curriculum in Ghana during TIMSS 2011

The relevance of students' math skills cannot be overemphasised. This is because it is so important to success in so many different areas of life. Therefore, math must be taught and learned at the pre-tertiary level of education in Ghana, also called basic education. Because math is so important, MoE (cited in Butakor, 2015) believes the state is taking steps to make sure that all Ghanaian students get the math skills, knowledge, attitudes, and values they need to be successful in their daily lives and careers. For example, in 2002, the government of Ghana set up the Anamuah-Mensah National Education Assessment Committee (Agyei & Voogt, 2010; Anumel, 2012). This committee did a thorough study and made suggestions that were implemented in 2007.

The Curriculum Research and Development Division, now called NACCA, made the math curriculum for 2007. Its goal is to teach students basic math skills and knowledge. Also, it was meant to give all students basic math skills and knowledge that they could use later (Butakor, 2015).

The curriculum lists the subject content (themes) and skills that students will learn, as well as the activities that will be used to teach, learn, and test them, and how much time will be spent on each. The math curriculum for elementary school is divided into units and is meant to last six years. The math curriculum for junior high school is also divided into units and is meant to last three years (Butakor, 2015). Information and understanding, as well as how to use what you know, are the key significant aspects of math teaching and learning, but the way they are stressed in Grades 1–3 and 4–6 and Grades 7–9 is different (Butakor, 2015).

In elementary school, the curriculum indicates that 40 % of learning time should be spent on getting information and understanding it, and 60 % on putting it to use. According to the curriculum for junior high school, students should spend 30% of their learning time on knowledge and understanding and 70% on how to use what they have learned. But even if the curriculum is supposed to put more emphasis on how to use what you know, classrooms often put a lot more emphasis on what you know and how you understand it. This level teaches the following skills: how to use numbers well, how to read and understand data, how to solve problems using computations and mathematical reasoning, how to think logically, and how to communicate using correct mathematical data and interpretations (Anumel, 2012). The curriculum is set up based on the subjects (the content) and specific goals, which include concepts, activities for teaching and learning, and ways for teachers to evaluate students. Lessons are also given specific amounts of time. The work for each year is broken up into units so that it can be used for six years of elementary school and three years of junior high school.

Based on the 2007 curriculum, here are the core areas of math for elementary and junior high schools. At the elementary school level, math instruction focuses on given students the mathematical knowledge and skills they need to function well in society (Butakor, 2015). Some of the skills that are taught are how to use numbers correctly, how to read and understand data, how to think logically, how to solve problems that involve computations and mathematical reasoning, and how to communicate with others using accurate mathematical facts and interpretations. Also, students need to be interested in math and be able to ask questions using math concepts (Anumel, 2012). At the junior high school level, the math curriculum focuses on algebra, estimation and measurement, data collection and manipulation, problem solving, and exploring numbers, sets, relations, and functions (MoESS, 2007). The goal is for students to learn how to analyse, compare, differentiate, and pick out the most important points. They are also expected to think of, plan, and put together new ideas and solutions. In addition, students must evaluate (compare), discuss (critique, justify, and support), draw conclusions, and make recommendations. Numbers covers how to read and write numbers with bases of ten, two, and five. It also teaches the four basic ways to work with numbers, such as ratio, proportion, percentage, fractions, integers, and rational numbers. Investigations of numbers give students the chance to find patterns and relationships between numbers and use the four operations well. Geometry is the study of solids, planes, forms, and how they interact with each other (Butakor, 2015). Estimation and measurement involve actions that result in estimates and measurements of length, area, mass, capacity, volume, angles, time, and money (Butakor, 2015). Algebra is about formulas, relations, and functions. These ideas are used to show how numbers relate to real-world activities. Students in Statistics and Probability must collect, organize, draw, and evaluate data from different sources. They also must understand the basic ideas of probability so they can use them in real life (MoESS, 2007). The math curriculum for 2007 called for a change from a "teacher-centred" to a "participatory" way of teaching and learning, where students learn by trying things out and using their problem-solving skills (Ampadu, 2014).

Ghana's scores on the TIMSS mathematics content and cognitive tests in 2003 and 2007 led to changes in the math and science curricula. Synthesis and evaluation, which are higher-level thinking skills, are being added to the junior high school curriculum (Anumel, 2012).

An Overview of the Education System in Singapore during TIMSS 2011

Singapore's educational system consists of 6 years of primary school, 2 years of lower secondary school, and 2 years of upper secondary school. Students may then pursue two or three years of pre-university education at junior colleges and centralised institutes, enrol in polytechnics or other institutes, or enter the workforce (Mullis et al., 2012).

Primary school, secondary school, pre-university, and tertiary are the four general levels of Singapore's education system. 6 years of elementary education (begins at age 6). The elementary school consists of two stages: the foundation stage (ages 6 to 10) and the orientation stage (Age 11 to 12). At the conclusion of the sixth year, students are required to take the Primary School Leaving Examination (PSLE). Students pursue secondary school in either Special, Express, Normal (Academic), or Normal (Technical) courses according on their PSLE scores. Students in the special or express programmes take the "Singapore Cambridge General Certificate of Education Ordinary Level," or O-level, while students in the normal (academic) or normal (technical) courses take the GCE "N" levels after four to five years of education (Mullis et al., 2012).

Instructional language

Singapore's population is multi-ethnic and its language environment is diverse. Official languages are Malay, Chinese (Mandarin), Tamil, and English. The national language is Malay. Despite having four official languages, English is the administrative language and the language most

Singaporeans speak. Except for mother tongue classes, many school topics are taught in English in Singapore's education system (Mullis et al., 2012).

Singapore's math curriculum

Important is the evaluation of both countries' curricula in the sense that we must comprehend and be current on the curriculum structures or designs of education systems that consistently produce high proficiency in mathematics and science at the fourth and eighth grade levels.

Singapore's curriculum is uniform across all grade levels, changing mainly in the level-specific elements and emphasising the same concepts. The Singapore mathematics curriculum is defined by the Mathematics Curriculum Framework (see Figure 2), which emphasises the development of students' mathematical problem-solving skills (Ministry of Education, Singapore, 2011). The development of problem-solving skills is supported by five interrelated components: concepts, skills, processes, metacognition, and attitudes. Mathematics instruction, learning, and evaluation are guided by the curriculum framework. Table 3 summarises the concepts and abilities to be covered by the end of eighth grade (Secondary 2).

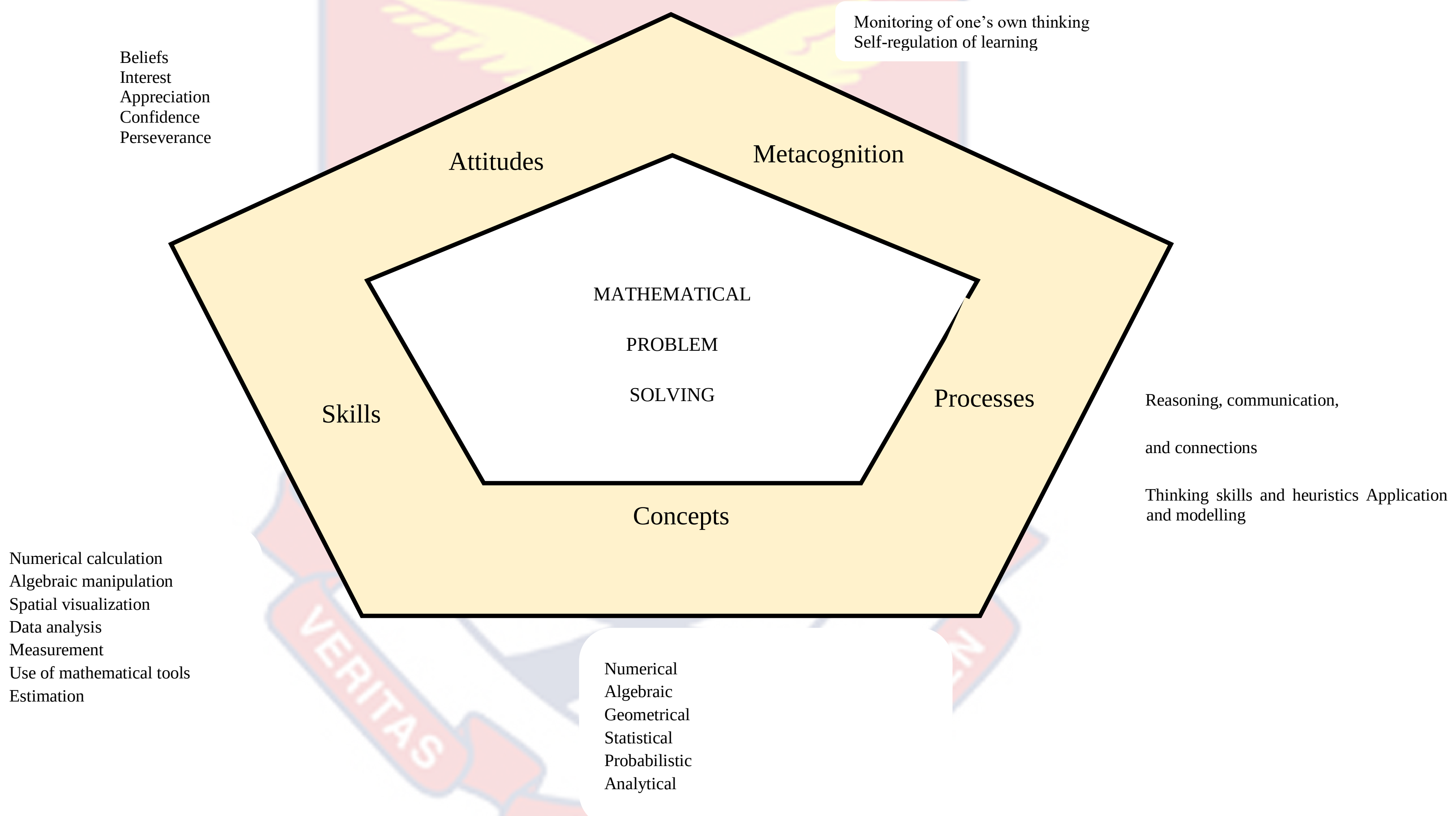

Figure 2: Singapore Mathematics Curriculum Framework. Source: (Ministry of Education, Singapore, 2011)

Table 3: Mathematics Concepts and Skills

Primary Mathematics Grade 1-6 Numbers and Algebra	Lower Secondary Mathematics Grade 7-8
Whole numbers, fractions, and decimals and the four arithmetic operations (addition, subtraction, multiplication, and division); Calculation with calculators; Factors and multiples; Ordering of numbers; Approximation and estimation; Percentage; Ratio; Speed; and Algebraic expressions in one variable".	Negative numbers, integers, rational numbers, and real numbers, and the four arithmetic operations addition, subtraction, multiplication, and division); Calculation with calculators; Prime numbers, highest common factor, and lowest common multiple; Ordering of numbers; Use of symbols including $<, >, \leq, \geq$; Approximation and estimation; Percentage; Ratio, direct and inverse proportion; Map scales; Rate and speed; Algebraic expressions and formulae; Algebraic manipulation (linear and quadratic); Functions and graphs (linear and quadratic); Linear equations with one unknown; Simultaneous linear equations with two unknowns; Quadratic equations; Linear inequalities with one unknown; and Set language and notation.

Table 3: Continued

Geometry and Measurement	
Measurement of length, mass, volume, time, and angle; Area and perimeter of triangles, squares, and rectangles, area and circumference of circles, and volume of cubes and cuboids; Properties of simple geometric figures; Nets of simple solids; Line symmetry; and Ideas of tessellation.	Properties and construction of simple geometric figures; Angles associated with parallel lines; Angles of polygons; Congruence and similarity; Area of plane figures, volume and surface area of three-dimensional solids; and Pythagorean Theorem.
Statistics and Probability	
Picture graphs, bar graphs, tables, line graphs, and pie charts (including interpretation and use of information.	Data handling (including data collection and representation); Data analysis (including interpretation and analysis of various statistical representations); and Probability.

Source: TIMSS (2011)

Teacher education in Singapore during TIMSS 2011

The ministry hires the top one-third of each cohort's instructors. A panel, including experienced principals, interviews and carefully selects applicants. Teachers are mainly recruited from among university graduates as well as from the A-Level and polytechnic graduate pools. Competitive terms of employment also attract mid-career professionals from other industries who can inject real-world experience into their teaching. One in eight teachers is a mid-career professional. Mathematics and science teachers in secondary schools and in junior colleges must be university graduates in the relevant subject (Mullis et al., 2012).

All prospective teachers are required to undergo pre-service teacher education conducted by the National Institute of Education (NIE), an institute at Nanyang Technological University. Many of the prospective teachers are university graduates in their chosen discipline. To make sure they're ready to teach in the classroom, they also go through a one-year Postgraduate Diploma in Education programme at NIE (Mullis et al., 2012). NIE also offers a four-year full-time programme leading to a Bachelor of Arts or Science degree with a Diploma in Education. Non-degree programmes include a two-year Diploma in Education offered to A-Level graduates and polytechnic diploma holders, and four-year diploma programmes offered to O-Level holders (for specialised areas such as home economics, art, and music). The teacher education programme at NIE is aligned with the national curriculum and is relevant to local classroom practices. Prospective teachers in the programme hone their skills in schools through teaching practises guided by experienced teachers. Beginning teachers receive structured induction and mentoring in schools, and teaching hours are reduced (by 20%) to ease them into their roles. Support for novice teachers continues after graduation (Mullis et al., 2012).

The Study's Conceptual Model

From the 1960s to the 1990s, many researchers, writers, and policymakers tried to figure out why some students learn more effectively than others and why certain school systems are highly successful than others (Ghagar, Othman, & Mohammedpour, 2011). This study seeks to compare two education systems (Ghana and Singapore) and determine what makes the Singapore school system more effective in terms of eighth-grade mathematics proficiency, as indicated by its consistent top-performance in TIMSS across the years of participation. Research suggests that an answer to these concerns may lie in inputs, process, and context, which is generally referred to as school effective theory (Huitt, 2003). Thus, various models and theories (Ghagar et al., 2011; Rumberger & Palardy, 2004; Carroll, 1963; Huitt, 1995; Shavelson, McDonnell, Oakes, Carey, & Picus, 1987; Walberg, 1984) were created and utilised in the study of school effectiveness. The objective of school effectiveness analysis is to enhance educational practise by examining what makes a school effective. Students' achievement is influenced by contextual elements such as students, classroom and school, according to the school's research.

Numerous conceptual models (Rumberger & Palardy, 2004; Shavelson et al., 1987; Willms, 1999) have been created and utilised in school effectiveness research (Rumberger & Palardy, 2004; Shavelson et al., 1987; Willms, 1999). All have defined and conceptualised the education process as a multilevel system in which student achievement is influenced by variables at the student-, classroom-, and school-levels (e.g., school emphasis on academic achievement). In addition, these models portrayed the educational process as consisting of three separate components: inputs, processes, and outcomes (Mohammedpour, 2012). Figure 3 was adopted from Rumberger & Palardy (2004), which present a model of the schooling process, for the current study.

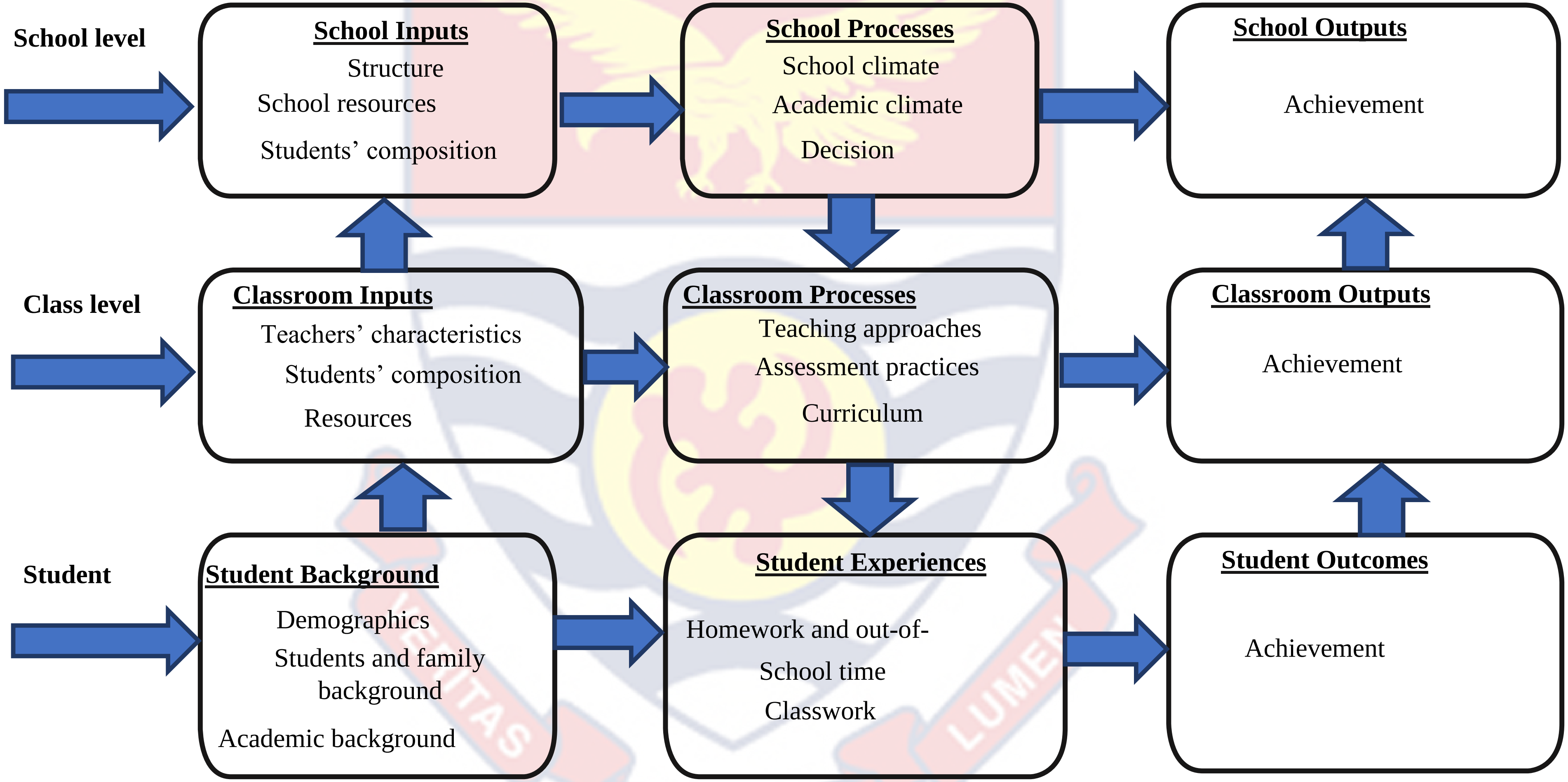

Figure 3: A Multilevel Conceptual Framework
Source: Rumberger & Palardy (2004)

The schooling process is predicated on the premise that student progress is mostly controlled by family background and school practises (Willms, 1999). The model indicates that the educational process operates on three levels—student, classroom, and school—and identifies inputs and processes as the two primary factors that influence student accomplishment. The model's inputs (Figure 3) include the financial, infrastructure, instructional, and personnel resources that the school has at its disposal, as well as characteristics of students (e.g., students like math, students value math, and students' confidence with math), teacher characteristics (e.g., confidence with teaching math and level of education), and school characteristics (e.g., discipline and safety and safe and orderly school). The process components of the concept include qualities such as quality of instruction (e.g., instruction approaches and assessment processes) and social and academic setting (Butakor, 2015). According to Ghagar et al. (2011), "the process refers to the content and method of instruction" (p. 288). Therefore, processes reflect who offers instruction and how it was arranged.

The model's outputs, such as academic achievement, are the final outcomes or products of the experiences and interactions that children from diverse backgrounds face during the education process. The outputs also represent the real achievement of students. The link between the model's components does not demonstrate a cause-and-effect relationship; it merely identifies the direction of the effects (Mohammedpour, 2012). For instance, input factors such as physical resources and policy-related elements at the national, regional, and school levels have a direct influence or impact on school climate and academic climate, which in turn will have a direct effect on student accomplishment (outputs) (Ghagar et al., 2011). Moreover, students' backgrounds at the input level would immediately influence instructors' qualities such as teacher quality, homework, and out-of-school time at the process level, which would ultimately impact students' accomplishment at the output level. Lastly, process-stage teaching approaches have a direct impact on outputs.

This study's selection of the input-output (IOP) model was influenced by the following factors: Firstly, the IOP model has been utilised extensively in large-scale data analysis investigations in recent years (Butakor, 2015; Mohammedpour, 2012; Chepete, 2008; Kaplan & Elliott, 1997). Mohammedpour (2012), for example, used TIMSS 2007 data to model and examine student, classroom, and school aspects that significantly contribute to mathematics achievement in his work. Butakor (2015) also utilised this conceptual framework to examine variables that contribute to eighth grade mathematics in Ghana. Similarly, Chepete (2008) selected variables for modelling the determinants that predict eighth-grade mathematics achievement in Botswana using this conceptual model. Second, it provides a comprehensive understanding of students' classroom learning and an extensive coverage of educational accomplishment indicators (Ker, 2016).

Thirdly, the model's multilevel structure (i.e., student-, classroom-, and school-levels) allows it to manage the nested nature of TIMSS data successfully. The model is therefore deemed appropriate for the investigation of the TIMSS data. This model is one of the most significant for improving and understanding students' academic progress in educational effectiveness research (Butakor, 2015). As illustrated in Figure 3, there are numerous elements that either have a direct impact on student achievement or indirectly contribute to it.

Theoretical base for the Study

This session discusses Bio-ecological Systems Theory (BST) which has been utilised in this study.

The Biological Systems Theory

The BST provides a framework for looking at the different factors that affect human development by considering the influences on an individual‘s development within the context of the complex system of relationships that form his or her environment (Nyatsikor, 2019). The theory indicates that, whiles biological factors are important for development, individuals create the environments that help shape their own development (Upton, Taylor, Erol & Upton, 2014). According to Bronfenbrenner (2005) development takes place through processes of progressively more complex interaction between an active individual and the persons, objects and symbols in their immediate environment. The theory positions the individual at the centre of various circles organised in hierarchy, from the most proximal (micro) to the most distal (macro) from the person, representing the various contexts in which the individual is positioned (see figure 4).

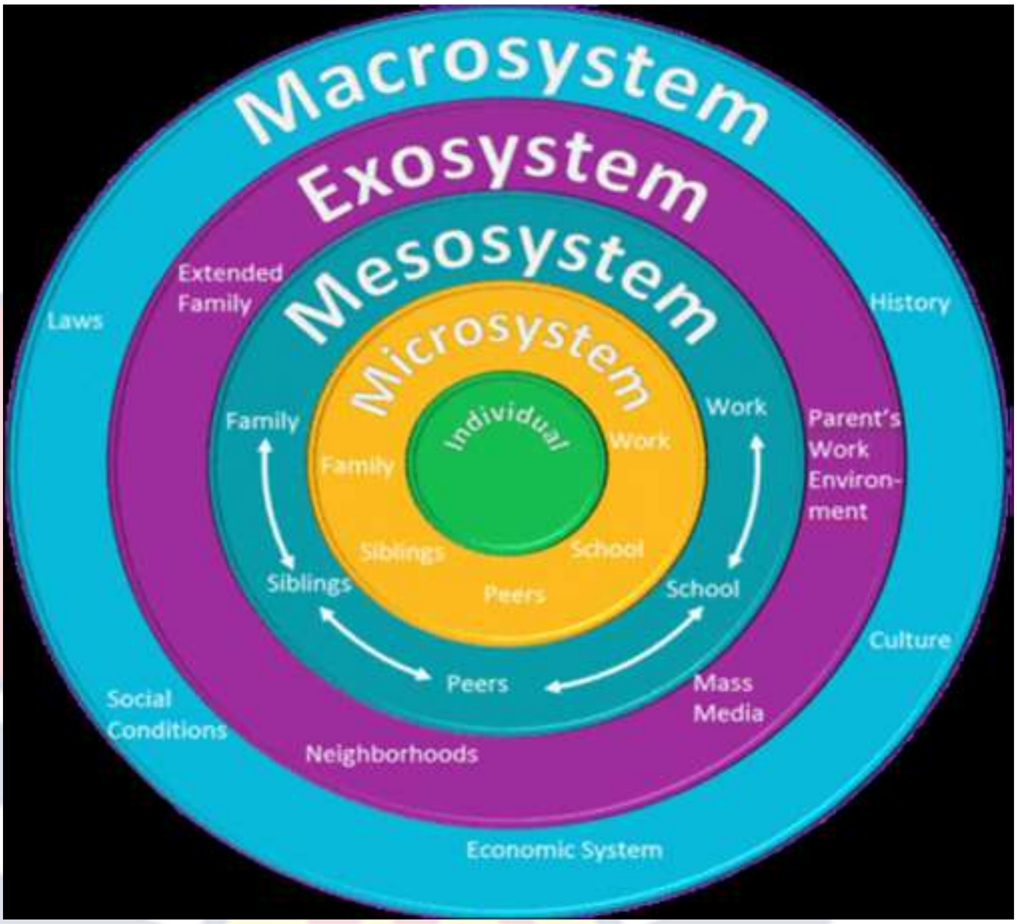

Figure 4: Model of the bio-ecological systems theory

A core proposition by the BST is that development always occurs in a particular social context and this context can change development. Humans should therefore be able to develop those settings to elevate their genetic potential (Bronfenbrenner, 2005). Bronfenbrenner (2005) believed that the most important setting for individual is their family, because that is where they spend the most time through their extended family, early care and education programmes, and community learning sites such as libraries are equally important. Bronfenbrenner (2005) stressed that for development outcomes to be exploited and effective the interaction must occur on a fairly regular basis over extended periods of time. Such long-term forms of interaction by the individual in the immediate environment are referred to as proximal processes.

The theory further proposes that the form, power, content, and direction of the proximal processes vary systematically as a joint function of the biological characteristics of the developing person and the environment (both immediate and more remote) in which the processes are taking place (Bronfenbrenner & Ceci, 1994; Bronfenbrenner & Morris, 1998). Basically, the BST stipulates that the:

(1) person is an active player, exerting influence on his/her environment;

(2) environment is compelling person to adapt to its conditions and restrictions and;

(3) environment comprises reciprocal relationships of microsystem, mesosystem, exosystem and macrosystem.

The essence and process of the BST is captured in a four-element model namely: (i) Process (ii) Person (iii) Context and; (iv) Time (Bronfenbrenner, 2005; Bronfenbrenner & Evans, 2000). These elements are explained in the subsequent sessions.

Process element

According to Bronfenbrenner and Crouter (1983) ‘process’ is that which could explain the connection between some aspect of the context (e.g. social class) or some aspect of the individual (e.g. student’s attitude) and an outcome of interest (e.g. mathematics achievement). For proximal processes to be effective, the interaction must occur on a fairly regular basis over extended periods of time (Bronfenbrenner & Morris, 1998).

Child-child activities; reading; group or solitary play and are specific examples of interactional activities that can explain the ‘process’ element of the theory. According to Bourdieu (1977), the extent and form of interaction is also influenced by the explicit understanding about cultural canons of knowledge and taste which in turn influences the success or otherwise in establishing relevant student-parent-teacher relationships. Bronfenbrenner (2005) hypothesizes that these activities and opportunities constitute the enablers of development because it is by engaging in these activities and interactions that individuals come to make sense of their world and understand their place in it. The ‘process’ element of the theoretical model also supports the idea that the environment can influence the extent to which the individual achieves specific outcomes of interest (e.g., mathematics achievement though the contribution of the biological characteristics and endowments of the individual is not discounted (Nyatsikor, 2019).

Person element

According to the BST, the personal characteristics individuals bring with them into any social situation strongly determine their levels of achievement of outcomes of interest (Bronfenbrenner, 2001; Bronfenbrenner & Morris, 1998).

The “person” element of the BST also advocates that individuals display different levels of change in their context based on which aspect of their personal characteristics is tasked. This change can be passive, more active and most active. Passive change involves the situation where a person changes the micro or macro environment simply by being in it, to the extent that others react to him or her differently on the basis of demand characteristics such as age and attitudes (Nyatsikor, 2019). More active change is where the changes in the environment are linked to the resource characteristics (e.g. physical, mental, and emotional) of the person (Nyatsikor, 2019). Most active change on the other hand, refers to the extent changes in the environment are linked, in part, to the force characteristics (e.g. desire, drive, or motivation) of the individual. The theory suggests that the biological and psychosocial aspects of persons contribute to the achievement of developmental outcomes including academic achievement in this context (Nyatsikor, 2019).

Context element

The BST proposes that humans develop within four interrelated contexts or systems namely: microsystem, mesosystem, exosystem, and macrosystem (Bronfenbrenner, 2000). The following sessions explain these concepts.

Microsystem

The microsystem refers to any environment, such as home (family), school, or peer group in which the developing person spends a good deal of time engaging in activities and interactions (Bronfenbrenner, 1989; 1994). Bronfenbrenner (2005) suggests that the most proximal and significant sphere is the individual's microsystem. Within this system are the patterns of activities, roles, and interpersonal relations experienced by the developing person in a given face-to-face setting. It is in the microsystem that the most direct interactions with social agents such parents (including other household members), teachers, peers and playmates in school and neighbourhood take place (Nyatsikor, 2019).

In the school, teachers influence the child through their actions and behaviours and the child also influences the teacher through their personal characteristics, experiences and feedback. Within the microsystem are the strongest influences on the child though interactions at outer levels can still impact the inner structures. The quality of an environment in a microsystem such as home or school has been strongly associated with students learning outcomes (e.g. Jeynes, 2011; Goldberg, et al., 2008; Osher, et al., 2014).

The mesosystem

The mesosystem is a system of microsystems. It focuses on the connections between two or more different microsystems or contexts, such as the home, playground, and school (Bronfenbrenner, 1979; Christensen, 2010). For example, the kind and quality of interaction within a child's home may influence the nature and level of interactions between a child and teachers or peers in schools or playgrounds. Children whose parents have rejected them may have difficulty developing positive relationships with teachers which is necessary for effective teaching and learning leading to improved outcomes (Bronfenbrenner, 1979; Christensen, 2010). The cascading effects of family experiences to school experiences and vice versa; family experiences to peer experiences and vice versa exemplify the dynamics of the impact of mesosystem on a developing person (Nyatsikor, 2019).

An instance is when teachers (school microsystem) and parents (home microsystem) effectively collaborate and complement the effort of each other in the learning process of a child (Bronfenbrenner, 1979). With reference to the BST, one particular aspect of school-family links is parental involvement in their children's school activities and the values they place on education (Westerlund, et al., 2013; Goodall, 2013). When parents attend school meetings or visit periodically to learn at first-hand about the strengths and weaknesses of their children, they will be in a better position to find effective ways to support them at home. It is instructive to note that the idea behind microsystems is not geography but an individual's degree of participation in any system (Nyatsikor, 2019).

The exosystem

The exosystem contains both micro and meso systems and impacts the wellbeing of all those who come into contact with the child. It encompasses the linkage and processes taking place between two or more settings, at least one of which does not ordinarily contain the developing person, but in which events occur that influence processes within the immediate settings containing the person (Bronfenbrenner, 2005; Bronfenbrenner & Morris, 2006). In this instance, the child does not directly encounter the system, but it impacts his or her development positively or negatively because the structures in this layer interact with some structures in the child's microsystem (Berk, 2000). Parents' workplace schedules or community-based family resources are two examples that explain the influence of exosystem on both meso and micro systems (Nyatsikor, 2019).

The macrosystem

The macrosystem describes the overall societal culture in which individuals live and its influence penetrates through all the other lower level layers (Bronfenbrenner, 1989; Bronfenbrenner & Morris, 1998). This system encompasses any group whose members share values or belief systems, resources, hazards, lifestyles, opportunity structures, life course options and patterns of social interchange (Bronfenbrenner, 1993; Trudge, et al., 2009).

The macrosystem stipulates that for any particular value system to have any influence on a developing person it has to be experienced within one or more of the microsystems in which that person is situated. For example, if it is the belief of a particular culture that parents should be solely responsible for educating their children, that culture is less likely to provide resources to help parents (Nyatsikor, 2019). This, in turn, affects the structures in which the parents function and their chances to cope with the task of education (Paquette & Ryan, 2001). The parents' ability or inability to carry out that responsibility toward their child within the context of the child's microsystem is likewise affected (Nyatsikor, 2019).

Chronosystem (time) element

The final element of the BST theoretical model is time and it encompasses various aspects such as chronological age, duration and nature of periodicity as it relates to a child's environments. The theory proposes that elements within this system can be either external, such as the timing of a parent's death, or internal, such as the physiological changes that occur with the aging of a child (Berk, 2000; Bronfenbrenner, 1990). As children get older, they react differently to environmental changes and able to determine how that change will influence them. According to Bronfenbrenner and Morris (1998) time could be compartmentalised into micro-time, meso-time and macro-time across the lifespan of an individual. Whereas micro-time emphasises on what is occurring during the course of some specific activity or interaction, meso-time focuses on the extent to which activities and interactions occur with some consistency in the developing person's environment (Nyatsikor, 2019).

Macro-time refers to the fact that developmental processes are likely to vary according to the specific historical events that are occurring as the developing individuals are at one age or another. Tudge, et al. (2009) propose that time, as well as timing is equally important because all aspects of the 'Process', 'Person', 'Context' and 'Time' can be thought of in terms of relative constancy and change in all spheres of development (Nyatsikor, 2019).

Moreover, national curricular and educational policies in specific countries continually change at differing pace at different times in their developmental trajectories (Nyatsikor, 2019). The connections between the elements proposed by the BST and the variables available in the dataset are presented in figure 5.

Justification for the use of BST

The basis for the application of this theory to the study lies in the approach it adopts to explain the connections between specific variables and learning achievement, which is similar to the conceptual framework utilized in the current study. The BST was applied because some of the proposed variables and the contexts in which they operate were specifically captured in the TIMSS dataset. For example, the impact of the characteristics of students, classrooms, and schools on learning outcomes (e.g., mathematics) is specifically proposed by the theory and also found in the TIMSS dataset. In my opinion, the application of the BST theory provides a robust framework for explaining the links between the variables contained in the dataset and students' learning outcomes or achievement, which resonates with the specific purposes of the current study.

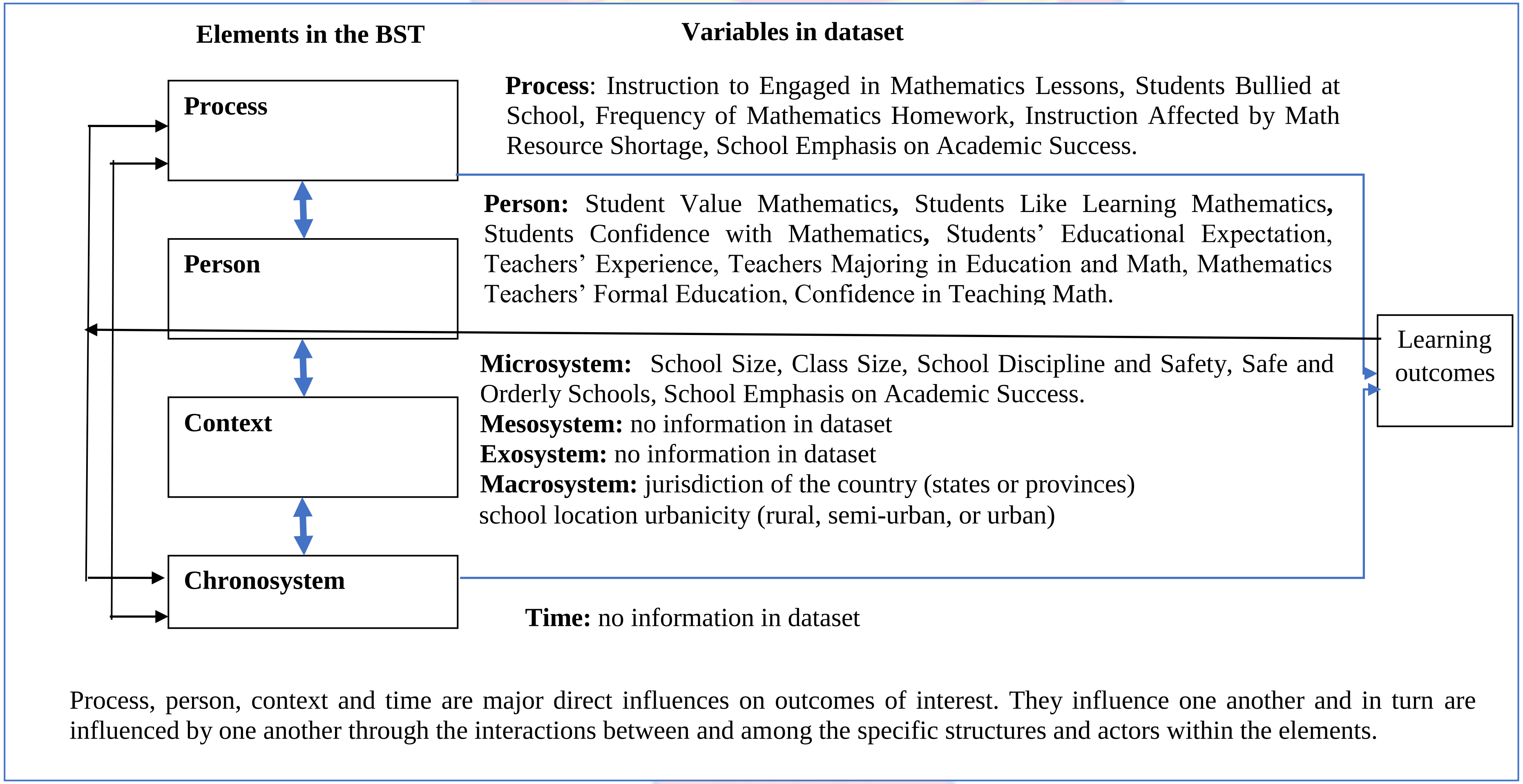

Figure 5: Connections between the BST and variables in the dataset

Limitations of BST

The structures in the micro, meso, exo, and macrosystems, according to the BST's critics, are numerous and diverse. According to the model's scope, practically every aspect of a person's environment has the potential to influence how they develop (Nyatsikor, 2019). Thus, it is quite challenging to rigorously conduct scientific experiments on the idea. The falsifiability requirement, which requires that assertions and theories be testable and defensible, is not met in this instance (Johnson & Christensen, 2016; Walker, 2010). Accordingly, a theory that can be refuted is considered scientific, whereas one that may never be refuted is not (Popper, as cited in Walker, 2010).

Second, the theory doesn't offer precise development mechanisms. The BST discusses the significance of connections between and among different system structures, but it doesn't go into detail on the precise mechanisms or ideal intensities of interactions required to achieve desired results (Nyatsikor, 2019).

Finally, it is very challenging to determine which of the two systems has a greater impact on development than the other. For instance, it is impossible to determine if failure to meet mesosystem needs has a higher impact on development than failure to meet exosystem needs.

Conclusion

In this session, the BST theory for the study was identified and supported. The BST was modified for the study despite the fact that other theoretical models (such as the dynamic model of educational effectiveness, the model of school learning, and the comprehensive model of educational effectiveness) also make an effort to model some factors associated with learning achievement. This is because the BST has a strong connection to the data, focus of the current study, and is adaptable in a variety of contexts. The BST is founded on the premise that students interact constantly in a range of contexts as they grow instead of developing in solitude. The ideas recognize that biological endowments and environmental circumstances work together to influence an individual's capacity to thrive in any endeavour, including academic success in schools.

The dataset's variables and the theory's variables were compared, and several of them were found to be strongly and directly connected. The databases included information on students' opinions, teachers' personalities, school contexts and psychological environments, and neighbourhood contexts and environments. It is anticipated that examining the relationships between achievement and these variables found in the dataset would help identify the factors that significantly (or not) influence how well students or pupils learn in both the Ghanaian and Singaporean contexts. The knowledge gained from this study could help foreign partners, governments, and politicians build efficient approaches to address the issue of academic underachievement.

Argument in Support of the Current Study's Selected Factors

This section focuses on the main factors that influenced the selection of the independent variable at each level of the hierarchy. As was already stated, there are several variables that either directly or indirectly affect how well students do in school (Ghagar et al., 2011). Therefore, the factors in this current study were selected mainly based on the conceptual model of this study; research evidence in terms of factors that contribute significantly to mathematics achievement; factors that can be easily implemented in Ghana's education system; factors that have a direct relationship with students' learning that can be manipulated through policy change, factors that policymakers can manage and improve within the Ghanaian contest; and the findings of MOE's mandatory analysis of TIMSS data. Finally, for the sake of consistency and effectiveness, it was decided to predominantly use or modify scales/indices from the TIMSS 2011 international data base.

In all, seven student-level factors, namely, math self-concept, like doing math, math valuing, students bullied at school, students engaged in mathematics lessons, educational expectations, and frequency of homework, were selected to investigate their contribution to mathematics achievement in both countries. These selected factors included six context questionnaire scales for the analysis.

For example, like doing mathematics was selected because of the following considerations: firstly, the model used for this study conceptualises attitude towards mathematics as a student background variable at the input level that has direct influence on homework and classroom work, which also have a direct influence on math performance. Secondly, the MoE report on TIMSS 2007 and TIMSS 2011 indicates that students who reported positive attitudes towards mathematics or who liked doing math scored highly in mathematics. Third, research has shown that students who have a good attitude about mathematics do better (Butakor, 2015; Mohammedpour, 2012; Else-Quest, Hyde, & Linn, 2010; Chepete, 2008). Lastly, this factor can be easily implemented in the Ghana education system if it is found to make significant contribution to mathematics achievement in the Singaporean education system.

Also, a total of fourteen classroom/school factors were selected, i.e., School Discipline and Safety, Safe and Orderly Schools, Teachers' Experience, School Emphasis on Academic Success, Frequency of Test, Teachers Majoring in Education and Math, Mathematics Teachers' Formal Education, Instruction to Engaged Students Learning, Teacher Condition of Service, Confidence in Teaching Math, Instruction Affected by Math Resource Shortage, School Size and Class Size, to assess their contribution to mathematics achievement in the two education systems. For example, the Frequency of Test was included in the classroom/school level factors for the following reasons: The MoE findings from TIMSS 2007 indicated that Ghanaian JHS Two's poor and abysmal performance was partly due to assessment practises experienced by these students over the previous 30 years. The researchers predicted that the 2011 results would not be different from the previous results (2003 and 2007) because, according to them, there was not much work done in assessment practises and curriculum overhauling (Anamuah-Mensah, Mereku & Ghartey-Ampiah, 2008). The TIMSS 2011 international report confirmed the predicted performance of Ghanaian students by these researchers. Based on this finding, the assessment practises (frequency of homework and frequency of tests) of teachers were selected for investigation in order to find out their contribution to mathematics achievement in both education systems.

Similarly, the school climate was selected for investigation because, firstly, positive school atmosphere was related with high levels of mathematical achievement, whereas negative school climate was associated with low achievement, according to the MoE report. Secondly, the conceptual framework conceptualises school climate as a school-level factor that has a direct influence on students' math achievement. Third, research has indicated that students who attend schools where instructors and school heads describe the school atmosphere as pleasant or positive perform better in math (Ghagar, Othman & Mohammedpour, 2011; Lubienski, Lubienski, & Crane, 2008). This finding means that the school climate influences the mathematics achievement of students. Finally, school climate was selected for investigation because it can be easily manipulated through policy change in Ghana's education system if found to contribute significantly to the Singaporean education system.

Factors that Contribute to Mathematics Achievement

There is a large body of literature on the factors that contributes to math achievement among students. Therefore, factors that contribute to or predict mathematics achievement (Walberg, 2003; Shin, Lee, & Kim, 2009; Lee & Shute, 2010; Sortkaer & Reimer, 2018; Peteros Gamboa, Etcuban, & Dinauanao, 2019; Evans & Field, 2020; Hiller, Kitsantas, Cheema, & Poulou, 2022) can be categorised as school -, classroom-, and student-level factors (Teodorovic, 2011). Therefore, the subsequent sessions will explore research reports that investigate how school-level variables, classroom or instructor-level variables, and student-related variables contribute to math achievement.

Student-level factors and mathematics achievement

Research has revealed that most of the diversity in student academic achievement may be related to student-level variables (Teodorovic, 2011).

According to Teodorovic student-level variables play a significant role in influencing student achievement in developing nations such as Ghana. Several student-related characteristics or variables, which can be split into three categories: attitude, personal, and socioeconomic factors, are supported by both empirical and theoretical evidence (Mohammedpour, 2012). For the purpose of this thesis, the review will be done according to the student level factors that were selected for investigation.

Attitudes towards mathematics

Research indicates that students' attitudes towards mathematics in eighth grade relate to their mathematical achievement (Evans & Field, 2020; Hiller et al., 2022; Ismail & Awang, 2012; Mohd, Mahmood & Ismail, 2011; Maamin, Maat & Iksan, 2021). Shavelson, McDonnell, and Oakes (1989) suggested that a system of education metrics that lacked certain attitude indicators would be universally seen as insufficient. Students' attitudes, such as mathematics self-concept (MSC), students' liking for learning mathematics (SLM), and students' value of mathematics (SVM), are crucial aspects that have been intensively researched. This may be owing to the determining importance of these variables in academic accomplishment and their manageability through the school teaching and learning process (Ma, Ma, & Bradley, 2008). The following section examines the three indicators (SVM, SLM, and SCM) of attitudes toward mathematics in this study and their contribution to eighth grade students' mathematical achievement.

Student value mathematics

Students' performance and motivation in learning math can be influenced by their perception of math as an interesting, important, or necessary subject for academic success and future professional aspirations (Ker, 2016). Developing such favourable attitudes about math among students is a significant objective of math education in many nations, including Ghana, a developing nation.

Values in mathematics have been defined as important and valuable attributes that are internalised by a person and provide him or her with the will and desire to pursue any path chosen in the learning and teaching of mathematics (Seah & Andersson, 2015; Seah, 2018). It is argued that values in mathematics education govern the alignment of a student's or teacher's cognitive abilities and emotional dispositions with mathematical learning components (Seah, Baba, & Zhang, 2017a; Seah & Andersson, 2015). Several research studies have examined the correlation between mathematics valuing and math performance (Mullis et al., 2020; Mullis et al., 2016; Mullis et al., 2009; Topcu, Leana-Ta, & Saclar, 2016; Butakor, 2016; House, 2003; Ker, 2017, 2016; Harmouch et al., 2017; Mohammedpour, 2012; Frempong, 2010).

However, conclusions from this research regarding the effect on students' mathematical achievement are inconsistent. TIMSS 2019 results, for instance, indicate that valuing mathematics was related to greater average achievement (Mullis et al., 2020). Butakor (2016) employed HLM to examine the association between attitude and instructional factors and math achievement. The results of the study indicated that appreciating mathematics positively correlates with average eighth grade mathematics achievement in Ghana. Frimpong (2010) observed comparable findings when he utilised TIMSS 2003 Ghanaian data to explore the education processes that offer Ghanaian students the opportunity to successfully study mathematics.

In contrast, Ker (2017) utilised TIMSS 2011 data to compare Singapore, United States and Chinese Taipei. The outcome suggested that SVM had no substantial impact on Singaporean and American students, but not on Chinese Taipei students. To explain why SVM was not a strong predictor of mathematics in Singapore, it was suggested that East South-Asian students, of which Singapore is a member, place less emphasis on mathematics despite being among the best achievers on a few international large-scale exams (e.g., TIMSS, PISA). This argument was backed by Mohammedpour (2012), who stated that despite the great performance of Singaporean students on TIMSS tests, the value of mathematics among Singaporeans is low in comparison to the international average. According to Ker (2017), this may occur due to the cultural background of Singaporean students, who are trained to have a moderate opinion of their own abilities and beliefs. Students from these countries (for example, Singapore) may be engaged in a challenging mathematics program, that allows them to perform better but makes them feel less secure in mathematics (Chepete, 2008). It is critical to stress that values in math education are thought to be linked to the sociocultural setting of math education (Chepete, 2008).

Student confidence in mathematics

Self-perception, according to Shavelson and Bolus (1982), is a person's perception of himself or herself; it encompasses how a student perceives his or her own strengths, shortcomings, abilities, attitudes, and values. Intellectual self-perception has been viewed as an individual's opinion of their general intellectual ability in school (Shavelson et al., 1976). According to Joyce and Yates (2007), it also refers to a student's interest in a particular course. This concept's significance has prompted several empirical investigations in the field of mathematics, which have culminated in the formation of a body of study known as "mathematics self-concept" or "confidence in mathematics" (e.g., Lee & Kung, 2018; Pajares & Miller, 1994). Thus, “mathematics self-confidence demonstrates a person's assurance in terms of his or her ability to master new mathematical concepts, excel in mathematics class, and perform well on mathematics exams” (Reyes, 1984, p. 560).

The variable contributes significantly and positively to mathematics achievement independent of subject, country, or grade level (Awang, Hashim, Selleh, & Tan, 2021; Mullis et al., 2020; Mullis et al., 2017; Topcu et al., 2016; Ker, 2017; Frempong, 2010; Butakor, 2016; Butakor, 2015; Yoshino, 2012). For example, Frempong employed HLM to look at Ghanaian TIMSS data from 2003 and revealed that male students who wanted to do well in school, liked math, and were sure of their ability to learn math did better in math. Similarly, Butakor (2015) discovered that student confidence in learning mathematics and the importance students placed on mathematics were positively associated with mathematics achievement in both TIMSS 2007 and 2011. Students with high educational goals and self-confidence in mathematics perform better in math (MoE, 2004).

Several research studies have demonstrated that among the three attitudinal components (SVM, SLM, and SCM), mathematics self-concept is the best predictor of students' maths achievement (Sevgi, 2021; Ker, 2016; Butakor, 2015; Butakor, 2016; Chen, 2013; Ghagar et al., 2011). Specifically, Chen (2013) revealed that student confidence in math was the greatest of the six relevant indicators at the student level in Singapore. Similarly, Sevgi (2021) discovered that the most impactful attitude element on math achievement was self-confidence in math learning. “Students who are confident in their abilities to understand school subjects or perform well are more likely to study more, spend more time studying, and achieve more than those who lack confidence” (Moller & Pohlmann, 2010, p. 34).

Students like doing mathematics

Students' enjoyment in maths is one measure of their attitudes toward mathematics. Since 1995, there has been a correlation between students' enjoyment of mathematics and higher average math achievement in every TIMSS cycle (Mullis et al., 2020; Mullis et al., 2016). Since TIMSS 2011, the "Students enjoy Learning Mathematics" scale has demonstrated a very strong relationship with math achievement, and TIMSS 2019, the most recent TIMSS series, was no exception (Mullis et al., 2020; Mullis et al., 2016). The 2019 TIMSS results indicate, for instance, that the average accomplishment gap between eighth-grade students who "very enjoy" learning mathematics and those who "do not enjoy" learning math is 62 scale points (Mullis et al., 2020). This demonstrates the contribution of this attitude variable to mathematics achievement among students. This finding supports prior research in Ghana, Singapore, and other locations (Frempong, 2010; Butakor, 2015; Butakor, 2016; MoE, 2004; Chepete, 2008). For example, Frempong (2010) found that boys who wanted to do well in school, liked math, and mentioned they were confident in their capacity to learn math did better than their counterparts. According to a report from the Ministry of Education in Ghana (MoE, 2004), students who wanted to do better in school and liked math a lot did better in math achievement. Recent research conducted by Butakor (2015) verified this finding. He discovered that students who enjoyed learning math achieved better in math than those who disliked the subject.

TIMSS 2019 results also showed that Singaporean students who expressed a preference for mathematics outscored those who indicated a preference for mathematics by a wide margin (Mullis et al., 2020). Similarly, students in Botswana who agreed to enjoy mathematics, be good at mathematics, and understand most of the mathematics outperformed those who did not by a statistically significant margin (Chepet, 2008). Chepete's study paralleled the conclusion of a report by the Botswana Ministry of Education, which stated that most children enjoyed math, which improved their academic performance (MoE, 2005).

Students bullied at school

In general, bullying consists of aggressive or negative behaviour intended to annoy less physically or mentally powerful individuals. Mullis et al. (2012) believe that there is mounting evidence that school violence is on the rise, particularly as cybercrime has become more prevalent, and that bullying harms students' academic performance. TIMSS 2011 introduced the students bullied at school scale to give information regarding bullying in participating countries. The results showed that eighth-graders who were bullied at school did worse on average in math than those who were bullied about once a week (Mullis et al., 2012). The average math grade of individuals who were bullied about once a week was 32 points lower than the average math grade of people who were bullied almost never. This result is consistent with several investigations (Lai, Ye & Chang, 2008; Mullis et al., 2012; Mullis et al., 2020; Topcu, Erbilgm & Arikan, 2016; Yalcin, Demirtasli, Dibek & Yavuz, 2017). These studies demonstrate that students who are bullied at school perform less well in mathematics. For instance, Topcu et al. (2016) discovered in their study that the absence of school bullying strongly predicted mathematics achievement. School bullying is a delicate subject that must be examined comprehensively. This is due to the importance it plays in students' overall academic progress. For instance, Mullis et al. (2012) found that students who attended schools with chaotic surroundings indicated higher bullying incidents and significantly worse academic attainment than their peers who attended schools with safe and orderly environments. Negative school impression and bullying may have an adverse effect on students' mathematical proficiency. When students are bullied and have a negative opinion of their school, these circumstances might have a negative effect on the development of their emotional and, consequently, their math performance (Sharp, 1995). Additionally, bullying may result in academic, social, or psychological issues (Woods & Wolke, 2004).

Educational expectation

Educational ambitions or expectations are the first step in the establishment of an individual's educational journey (Dobewall et al., 2019). They are defined as abstract statements and opinions regarding students' future objectives, such as the desired level of schooling (Khattab, 2015). This characteristic is significant because of its ability to predict students' academic performance. Literature demonstrates that educational aspiration is a strong predictor of future educational trajectories (Reynolds, Pemberton & Rising 2001; Croll, 2009). Multiple studies have demonstrated the effect of this aspect on students' mathematical achievement (Sanders et al., 2001; Marjoribanks, 2002a, 2003b; Gil-Flores, Padilla-Carmona, & Suárez-Ortega, 2011). For example, Marjoribanks (2002, 2003a) found that students' academic aspirations contribute significantly to their educational success.

In addition, empirical research has demonstrated that students' educational ambitions influence their mathematics proficiency. Mullis et al. (2012) found that in eighth-grade countries like Ghana and Singapore, students with higher education expectations had better math skills on average than those with lower education expectations. Specifically, those anticipating a postgraduate degree showed much greater average success than those anticipating only upper secondary education.

In the African setting, empirical research has demonstrated that students' educational goals, i.e., their plans to seek higher education, are more strongly connected with student accomplishment than any other variable examined (Bofah & Hannula, 2015; Gil-Flores et al., 2011). Bofah and Hannula (2015) found that Ghana, South Africa, and Botswana, had the strongest correlation between students' plans for future education and their accomplishment. This echoes the findings of Chepete (2008), who discovered that the educational ambitions of Botswana students were the most accurate predictors of mathematical achievement. Frimpong (2010) revealed that eighth-grade Ghanaian students' educational aspirations related considerably to their mathematical proficiency. The ambition to obtain a university degree, he concluded, is the driving factor behind the successful study of mathematics. Similarly, Butakor (2015) noted that Ghanaian students with higher educational goals had higher test results than those with lower educational aspirations. Nonetheless, several studies have demonstrated a deleterious impact on mathematical achievement (e, g., Hammouri, 2004).

Frequency of homework

It is commonly accepted maths achievement is positively correlated with homework. Unknown is the extent to which homework contributes to mathematics achievement in various education systems, such as Ghana or Singapore. This is the essence of the inclusion of this variable in this study's analysis. Teachers can extend the time for learning beyond typical school hours, and students can consolidate and extend classroom learning through homework. It allows slow learners and weak students to spend more time outside of the classroom on classroom-taught material. Teachers evaluate students' comprehension of material covered in class based on their homework performance (Anamuah-Mensah et al., 2008). It is also utilised as a learning assessment and as learning. Thus, homework is employed as an assessment tool, providing students with learning opportunities.

Previous research indicates that the positive effect of homework on mathematics achievement is uncertain and inconclusive, as some studies have shown positive effects and others have found negative effects (e.g., Boddison, 2015; Dettmers, Trautwein, & Lüdtke, 2009). Nonetheless, several previous studies (Areepattamanil & Kaur, 2013; Dettmers, Trautwein, Lüdtke, Kunter, & Baumert, 2010; Pelletier, 2005; Fernández-Alonso, Suárez-lvarez & Muiz, 2015; Cheema & Sheridan, 2015; Ladson, 2012; Riley, 2007) have discovered significant positive effects on homework frequency. Despite the negative impact that some studies have shown homework to have on math accomplishment, other research have demonstrated that homework can also improve students' academic achievement and intellectual success (Ramdass & Zimmerman, 2011; Bembenutty, 2011; Rudman, 2014; Stoeger & Ziegler, 2008; Warton, 2001; Xu, 2005).

Classroom/school-level factors and student mathematics achievement

In addition to the student variables that have been proven as having a major effect on student accomplishment, classroom and school-level factors also contribute significantly to the math achievement of students, according to empirical studies. This review session focuses on the contributions of selected classroom/school variables to the mathematical achievement of students.

Instruction to engage students

The greater achievement of East Asian students in global comparative studies (e.g., PISA and TIMSS) of mathematical accomplishment (Mullis et al., 2012, 2016, 2020; OECD, 2013) has sparked a great deal of discussion about the underlying causes (Leung, 2005; Mohammedpour, 2012; Ker, 2017). Given that students acquire most of their math knowledge in the classroom, it is logical to assume that the instruction they get has a significant impact on their accomplishments (Leung, 2005). TIMSS 2011 examined student content engagement as a means of strengthening the connection between curriculum and instruction. (Mullis et al., 2012). TIMSS defines education that engages students as cognitive contact between students and instructional content, which may take the form of listening to the teacher or providing more explanations of problem-solving strategies (Mullis et al., 2012). Additionally, student engagement has been defined as "the possibility that students will be actively engaged in relevant mathematics during a class" (Hiebert, Morris, & Glass, 2003, p. 1). Studies conducted by TIMSS over the years reveal that students had somewhat higher average mathematics results if their teachers employed engaging instruction in many classes, as opposed to around half of the lessons. Consequently, there is a direct correlation between student engagement and mathematics achievement (Mullis et al., 2020; Mullis et al., 2016; Mullis et al., 2012). 63% of students whose instructors utilised engagement practises in most sessions outperformed 27% of students whose teachers used engagement practises in roughly half of their lessons, according to Singapore TIMSS 2011 results (Mullis et al., 2012). The Singaporean school system's findings reflect prior research. For instance, teacher efficacy, as demonstrated by teachers' teaching to engage students' learning, was discovered to be the most significant factor influencing student mathematical achievement (Sanders, Wright & Horn, 1997). Similarly, Daniel House and Telese (2016) indicated in their study that eighth-grade Korean students' mathematical views and classroom participation were substantially associated to their test performance. In addition, Fung et al. (2018) suggested in their study that students with a higher level of engagement had higher academic (mathematics) accomplishment.

In contrast, data from Ghana found that 10% of students whose instructors utilised engagement practises in around half of their courses outscored 90% of students whose teachers used engagement practises in most of their sessions. The difference in academic achievement between these two groups of students was 11 points (Mullis et al., 2012). Contrary to the findings of the Ghanaian educational system in TIMSS, Butakor (2016) found that Ghanaian students who were more involved in instructional practises performed better than those who were not.

Teacher job satisfaction

Teacher job satisfaction relates to teachers' attitudes and perceptions of their working environment and profession (Hongying, 2007). Teacher work satisfaction is one of the teaching elements that have garnered substantial examination. This could be because of its importance and far-reaching ramifications. For example, job satisfaction influences teacher performance and student achievement (Kunter, Klusmann, Baumert, Richter, Voss, & Hachfeld, 2013; Skaalvik & Skaalvik, 2011; Collie, Shapka & Perry, 2012).

International comparative studies (e.g., TIMSS) have established that, on average, eighth grade students taught by satisfied instructors performed better in mathematics than those taught by less satisfied teachers (Mullis et al., 2012; Mullis et al., 2016; Mullis et al., 2020). Similarly, other investigators found that students of teachers who are content with their employment and have a strong psychological sense of well-being likely to be more academically successful than those whose teachers are dissatisfied (McInerney, Korpershoek, Wang & Morin, 2018; Arens & Morin, 2016; Borah, 2019).

The direction of the influence of job satisfaction on mathematics achievement among students is ambiguous. Several studies have demonstrated a correlation between career satisfaction and mathematical proficiency (Liang & Jea, 2015; Tek, 2014; Su & He, 2020; Wu, Gao, & Shen 2020; Iqbal, Fakhra, Farooqi & Shabbir, 2016). Specifically, Su and He (2020) discovered that instructors' job satisfaction significantly predicted students' mathematical achievement. Similarly, Iqbal et al. (2016) found a substantial relationship between instructors' job happiness and students' academic accomplishment;

that is, teachers with a higher level of satisfaction facilitate an increase in students' academic achievement. Specifically, TIMSS data revealed that eighth-grade Singaporean students with satisfied instructors outperformed those with dissatisfied teachers. In contrast, other studies have found a negative correlation between teacher work satisfaction and mathematical achievement among students. In their study, Mullis et al. (2012) found that Ghanaian students with less satisfied instructors performed better on average in mathematics than their counterparts with satisfied teachers. Approximately 70% of Ghanaian students were instructed by teachers who were at least somewhat content with their work. This reflects the conclusions of other research on the job satisfaction of Ghanaian teachers, demonstrating that job satisfaction among Ghanaian teachers is poor (Vulley, 2021; Nutsuklo, 2015; Anari, 2011; Azornu, 2011; Bennell & Akyeampong, 2007).

Still, other scientific investigations have documented no relationship between job satisfaction and the mathematics achievement of students. For example, findings for teachers in England show that a higher degree of professional satisfaction is not connected with higher student performance (Sturman, Burge, Cook & Weaving, 2012). Similarly, in their studies, Banerjee, Stearns, Moller, and Mickelson (2017) observed that job satisfaction of teachers had no relationship with students’ math growth and achievement. The discussions in the literature highlight that research findings are not conclusive in terms of the size and direction of the impacts of teacher job satisfaction on students’ mathematics achievement. This current study seeks to contribute to the debate.

Teacher working conditions

Teacher working conditions are one of the teacher characteristics that have been investigated together with job satisfaction in terms of their impact on students' academic achievement. Generally, there is a belief that teachers' conditions of service influence other variables such as students' academic achievement and teacher job satisfaction. This has been supported by several scientific studies. These studies observed that teacher working conditions are a significant predictor of students' outcomes and achievement (Bascia & Rottmann, 2011; Dobbie & Fryer, 2013; Kraft, Marinell, & Shen-Wei Yee, 2016).

Studies conducted on a global scale have observed the impact of instructors' working conditions and their influence on students' mathematical proficiency. According to the findings of these investigations, there is a correlation between the teacher's condition of service and student mathematics achievement. In other words, the higher the index of condition of service, the greater the accomplishment of students in mathematics (Mullis et al., 2012; Mullis et al., 2016; Mullis et al., 2020). Studies have shown that teachers' conditions of service, a major determinant of teachers' career satisfaction, contribute significantly to the mathematics achievement of students (Toropova, Myrberg, & Johansson, 2021; Kaniuka & Kaniuka, 2019; Dobbie & Fryer, 2013; Johnson, Ghildayal, Ward, Westgard, Boland, & Hokanson, 2012).

Confidence in teaching mathematics

Research shows that a teacher's confidence in his or her teaching skills is linked not only to how well they do their job but also to how well their students do (Henson, 2002). International studies (e.g., TIMSS, PISA) have established the impact of teacher confidence on eighth grade students' mathematics achievement. For instance, TIMSS 2011 data demonstrated that, on average, students whose instructors were highly confident in teaching math fared higher than those whose teachers were somewhat confident (Mullis et al., 2012). These results were validated by later TIMSS datasets (Mullis et al., 2016; Mullis et al., 2020).

Other research investigations have shown that a teacher's confidence in teaching math has a favourable effect on student achievement in mathematics (Liang & Jea, 2015; Ker, 2017). In other words, the results of these research indicate that teachers' confidence in the classroom increases the mathematical achievement of their students. Nonetheless, several studies have revealed that teachers' confidence in teaching mathematics has a negative and negligible effect on student mathematical achievement. Demirtasli et al. (2017), for instance, concluded that teachers' confidence in the classroom had no effect on student mathematical achievement.

In most East Asian nations, such as Hong Kong, Japan, Korea, and Singapore, teachers have the lowest degree of confidence in teaching mathematics among all TIMSS participating nations, according to research findings (Ker, 2017; Mullis et al., 2012). Surprisingly, students of these Asian teachers perform exceptionally well in mathematics on many international large-scale examinations (Mullis et al., 2012; Mullis et al., 2016; Mullis et al., 2020). This finding has been attributed, in part, to the fact that Singaporeans tend to have conservative self-perceptions despite setting high performance goals (Ker, 2017). Typically, they do not boast about their abilities, even when they possess them. Confidence may signal humility, which is regarded as a virtue in the cultures of most East Asian countries (Ker, 2016). On the hand, Ghanaian teachers exhibit a high level of confidence, but the students of these teachers consistently perform abysmally in international assessment (Mullis et al., 2012). It is hoped that the issues raised here will lead to more research into how culture affects math achievement in large-scale tests.

Teacher level of education

School makes a difference in students' achievement, but teachers are responsible for a considerable percentage of that difference (Anderson, 2004; Darling-Hammond, 2010). The most essential qualities teachers contribute to the classroom are teaching experience, educational qualification (degree of education), and field of study. The conceptual framework employed in this study refers to these as input characteristics at the classroom level.

Students' mathematical achievement is significantly influenced by the amount of education of their teachers, according to research (Casian, Mugo & Claire, 2021; Antony & Elangkumaran, 2020; Nyatsikor, 2019; Klassen & Dolan, 2015; Hanushek & Rivkin, 2006; Anamuah-Mensah et al., 2004, 2008). Anamuah-Mensah et al. (2004, 2008) analysed TIMSS data and discovered a high correlation between the academic credentials of Ghanaian instructors and their students' performance in mathematics. Students taught by teachers with at least a bachelor's degree had a statistically significant higher mean score than those taught by teachers without a bachelor's degree. Teachers with advanced degrees may have a stronger comprehension of the material to be taught. According to Shulman (1987), "instruction begins with a teacher's comprehension of what is to be learnt and how it is to be taught" (p.7). Teachers with bachelor's degrees were better knowledgeable in their specialised subject areas, enabling them to establish psychologically stimulating learning settings. Teachers with a higher degree of education were more likely to develop the confidence and drive to positively impact the contexts (schools and classrooms) in which they worked (Nyatsikor, 2019). A teacher who possesses a certain certification that has been shown to increase student progress would have a significant hiring advantage.

Other research, however, have shown that education level has no substantial effect on mathematical performance. A multilevel comparison research, for instance, revealed that educational degree had no significant effect on mathematical achievement (Lamp & Fullarton, 2002). Similarly, the academic credentials of teachers in Singapore had little effect on students' mathematical achievement. (Mohammedpour, 2012). Chepete (2008) similarly found that teachers' formal education had no significant effect on eighth graders' mathematical performance. These findings open the door for future studies to investigate why teacher qualification has little effect on the TIMSS math performance of the students in high-performing nations (such as Singapore).

Major of education

It is worth noting that currently in Ghana, the colleges of education, which were previously diploma-awarding institutions, have been upgraded to degree-awarding institutions. This was hinted at in the previous sections. This was based on research findings that the level of teachers’ formal education and major of education contribute positively to the overall academic performance of students. As a result, the minimum formal education required for teachers in Ghana is a first degree in a specialized field (e.g., Junior High School Mathematics), also known as a teacher major. This factor was included in the analysis to examine its contribution to mathematics achievement in both countries, validate the current teacher education reforms in Ghana as noted above, and provide evidence-based support for further and future reforms in teacher education in Ghana and elsewhere.

International large-scale studies (e.g., TIMSS) and other studies have documented the contribution of teachers' majors in education to the mathematics achievement of students (Mullis et al., 2012; Mullis et al., 2009; Mullis et al., 2016; Mullis et al., 2020; Butakor, 2015; Wayne & Youngs, 2003). For example, Wayne and Young (2003) discovered that when teachers have additional degrees or course work in math, students in high school learn more mathematics. Mullis et al. (2012) agreed with this finding. They indicated that students did better in math when they were taught by instructors who had majored in math and math education. Butakor (2015) also discovered that students taught by instructors who majored in mathematics outperformed students taught by teachers who did not major in mathematics. However, some studies found a negative and insignificant association between a teacher's major of study and the mathematics achievement of students (Mohammedpour, 2012; Chepete, 2008). Mohammedpour's study revealed, for instance, that teachers specializing in mathematics and mathematics education had no substantial impact on the mathematical performance of Singaporean students. The insignificant effect of this factor on the mathematics achievement of Singaporeans does not mean that it is of no concern in terms of the math performance of these students. It is generally expected that there would be a positive and significant effect of the teacher's major of study on high-performing students (e.g., Singaporean students). Singapore is one of the few countries that recruit only the top 5% of graduating students from teacher education institutes to become teachers. This measure demonstrates how quality and talented these Singaporean teachers are.

One of the possible explanations for this finding may stem from a lack of variability in this factor (Chepete, 2008). TIMSS 2011 international results indicate that 32% of students were taught by teachers who majored in mathematics and mathematics education, while only 6% of students were taught by teachers who majored in mathematics education but not mathematics, 45 % were taught by teachers who majored in mathematics but not mathematics education, and 17 % were taught by teachers who majored in all other subjects (Mullis et al., 2012). A critical look at the TIMSS international results reveals that the responses of the teachers were almost concentrated in one category, which is major in math and math education. In this case, estimating the significant effect may be ineffective or redundant. Despite the mixed findings in terms of the contribution of this factor to mathematics achievement, research has indicated that the major of the instructor influences student performance in favour of students taught by teachers who majored in math.

Mathematics resource shortage

It has been discovered that general academic resources, such as home learning resources, school resources, and subject-specific resources (e.g., mathematics), are related to students' mathematical achievement. This viewpoint is confirmed by global comprehensive investigations (Mullis et al., 2012; Martin et al., 2016; Mullis et al., 2020). According to Mullis et al. (2012), the average mathematics success gap between students attending schools where teaching was not significantly impacted by resource shortages and those who attended schools where instruction was significantly impacted by resource shortages was 35 points. Recent research by Mullis et al. (2020) confirmed prior TIMSS findings. Other studies have also demonstrated that the mathematical resource deficit has a major impact on children' maths performance (VaraidzaiMakondo & Makondo, 2020; Sullivan, Parry & McConney, 2013; Kalejaiye, 2005; Ale, 2000). In their study, VaraidzaiMakondo and Makondo (2020) discovered that appropriate mathematical resources improve students' maths performance. In a similar vein, Ale (2000) reported that a lack of acceptable materials for use by mathematics teachers exacerbates the issue of poor academic achievement in the subject. This suggests that schools with insufficient mathematics resources may have an impact on students' mathematical achievement. This position was supported by Lance (2002), who noted that shortages of critical materials, such as textbooks, had a negative impact on mathematics. However, some investigations have produced contradictory results (OECD, 2010; Ilie & Lietz, 2010; Woessmann, 2003). For instance, the 2009 PISA suggests that school resources are not significantly associated to student performance across countries (OECD, 2010). Similarly, Woessmann (2003) argues that there is no significant relationship between international variances in student success and inequalities in school resources.

School Climate

Research indicates that school climate influences academic accomplishment (Sevgi, 2021; Schmitt et al., 1999; Lubienski et al., 2008). Climate in the classroom supports teaching and learning, which invariably improves student performance (O'Dwyer, 2005). School atmosphere is one of the school-level variables that relates to students’ math achievement (Lee & Shute, 2010). These results are consistent with earlier TIMSS study results. Students with the highest mathematical achievement, according to Mullis et al. (2012), attend schools that prioritize academic success, as indicated by demanding curricular objectives, parental support effective teachers, and students' desire to succeed. Schools with concerns with discipline and safety, on the other hand, are not conducive to high academic achievement. Students who attended schools with disorderly environments apparently performed considerably worse than their counterparts who attended schools with safe and orderly environments (Mullis et al., 2020; Mullis et al., 2016). This section of the literature review focuses on selected indicators of school climate, such as safe and orderly schools, school emphasis on academic achievement, and discipline and safety.

Emphasis on academic success

Emphasis on academic performance is one of the components of the school's climate, which has a strong link with students' motivation and achievement (Scherer & Nilsen, 2016). Moreover, across all nations participating in international research (e.g., TIMSS), correlations between school emphasis on academic success and student performance on mathematics achievement exams have been identified (Mullis et al., 2020;

Nilsen & Gustafsson, 2014; Mullis et al., 2012). Additional research utilising secondary TIMSS data indicates that school emphasis has a significant impact on math achievement in several nations. (Ker, 2016; Mullis et al., 2012; Demirtasli, Dibek, & Yavuz, 2017). Using TIMSS data from the United States and Singapore, (Ker, 2016) investigated the influence of student-, teacher-, and school-level factors on mathematics achievement. The results indicated that a focus on student academic success had the greatest positive effect on Singaporean students' mathematical achievement. The emphasis on student academic accomplishment characterizes the cultures of top-performing East Asian nations such as Hong Kong, Japan, Korea, and Chinese Taipei (Ker, 2016). According to Ker (2016), both the cultures and teachers in these East Asian nations set high expectations on students' academic success. The presence of high instructor expectations for student accomplishment is critical to effective learning. Students can make significant improvements in their academic performance if schools communicate effectively with them, establish high expectations, listen to what they have to say and provide demanding learning activities (Ker, 2016). Similarly, Butakor (2015) discovered that an emphasis on the academic success of Ghanaian students related significantly and positively to their mathematics achievement. This review indicates that this variable is, to a greater extent, universal in terms of predicting math achievement. Even though this measure is influenced by culture and other factors, it appears to be a good predictor of math achievement.

Discipline and safety

School discipline and safety is another school-level variable that has garnered national and international attention for its contribution to mathematics achievement. As previously said, school discipline and safety is a manifestation of school atmosphere. Several studies have explored the impact of school discipline and safety on students' math performance (Mullis et al., 2020; Mullis et al., 2016; Ersan & Rodriguez, 2020; Chepete, 2008; Mullis et al., 2011; Mohammedpour, 2012; Butakor, 2015; Butakor, 2016).

The results of all TIMSS series indicate that discipline and safety variables consistently predict mathematical achievement, regardless of grade level, topics, and cultural and national factors (Mullis et al., 2020; Mullis et al., 2016; Mullis et al., 2011). For instance, Mullis et al. (2011) discovered that school discipline and safety predicted eighth - and fourth -grade science and math achievement. Similarly, Bear, Yang, and Pasipanodya (2015) concluded that school atmosphere was the sole significant predictor of science achievement among the three school-level characteristics included in their analysis. The findings of Bear et al. (2015) support the notion that a happy learning environment is more significant than science materials. School climate, as judged by head teachers, was the strongest important variable in Malaysia and Singapore (Ghagar et al., 2011). Similarly, Butakor (2015) showed that Ghanaian students whose principal and teachers had a positive impression of their school fared better than those whose principal and instructors had a negative perception of their school. This result is consistent with past research indicating that a pleasant school climate promoted mathematics learning and achievement among Ghanaian children (Lubienski et al., 2008).

In addition, Sevgi (2021) discovered a significant relationship between a principal's sense of school safety and mathematical achievement. Not only is this variable a strong and substantial predictor of mathematics achievement, but it also predicts scientific achievement. Establishing a friendly and supportive classroom atmosphere may have a higher influence on students test performance than teacher background. According to Van Horn (2003), school environment is a crucial component of a successful school that can accurately predict student mathematical proficiency. Literature demonstrated that schools with fewer rates of violence, larceny, and abusive language created a better learning environment for students (Chepete, 2008). Students in less safe situations, according to Chepete, had less time to focus on academic work because they were fearful of being victimized. Furthermore, some teaching time may be devoted to dealing with disciplinary concerns, whereas in schools with favourable climates, there would be fewer instances that disturbed the academic process. The preceding discussions indicate the resilience and importance of this factor in influencing or predicting student math achievement.

Safe and orderly schools

Another indicator or component of the school climate is the existence of safe and orderly schools (Mullis et al., 2020). There is empirical evidence that students' perceptions of school safety negatively impact their academic achievement (Martin & Mullis, 2013; Mullis et al., 2012; Milam, Furr-Holden, & Leaf, 2010; Chepete, 2008). TIMSS 2011 established a safe and orderly school for the inquiry in order to determine the extent to which school safety may be influencing mathematics achievement. The international results demonstrated that the safer the school, the greater the average mathematics achievement of the students (Mullis et al., 2012). Mullis, Martin, and Loveless (2016) claimed that a safe and orderly school is a necessity for establishing a supportive and productive school environment. They found that, of the school environment factors included in the TIMSS 2011 school effectiveness analysis (Martin, Foy, Mullis, & O'Dwyer, 2011), the Safe and Orderly Schools scale was one of the most important variables related to achievement in approximately half of the countries, even when controlling for the effects of family background.

Recent findings from TIMSS 2019 suggest that the majority of eighth-graders in less safe and orderly schools had significantly lower average achievement than those in very safe and orderly schools. There is a 41-point gap between the average mathematics achievement of eighth-graders in extremely safe and ordered schools and those in less safe and orderly schools. These research findings demonstrate the contribution of this variable to students' mathematics achievement (Mullis et al., 2020). In addition, the results indicate that the variable appears universal and stable in terms of its impact to mathematical achievement (Lay & Ng, 2019; Chen, 2013). For instance, Chen (2013) conducted a multilevel examination of low-achieving Singaporean children in mathematics. He discovered that the impression of school safety is a strong predictor of mathematical achievement. According to Chepete (2008), students in less violent and safer learning environments outperformed those in more aggressive and risky learning environments when he used TIMSS 2003 data from Botswana in his study. Butakor (2015) observed that Ghanaian students whose principals and instructors indicated safe and orderly schools outperformed those whose principals and teachers indicated schools with less safety and order.

School size

School quality, broadly construed, is a strong determinant of students' educational performance (Altonji & Mansfield, 2011). School size is one potential indicator of school quality that governments can influence. The number of potential students who have access to formal education at all levels is a factor in determining the size of a school. No Child Left Behind, adopted in 2002 in the United States, and the Free Compulsory Basic Education, School Feeding Program Policy, and current free Senior High School policy in Ghana, for instance, have increased access to formal education at all levels in both nations. Consequently, a rise in school enrolment.

However, the benefits of expanding access to formal education and the resulting increase in school size come with a price, as larger schools have higher rates of student absenteeism and social disorder, which may impede social and cognitive development (Gottfredson & DiPietro, 2011). Despite this, empirical data indicates a complicated association between school size and academic achievement of students (Cotton, 1996; Leithwood & Jantzi, 2009; Andrews, Duncombe & Yinger, 2002). Slate and Jones (2005), for instance, stated that research connecting school size to student achievement have shown contradictory results. While some studies indicate a positive relationship between school size and achievement (Howley, 1994), others demonstrate both curvilinear and negative effects (e.g., Borland & Howsen, 2003; Greenwald et al., 1996). Nonetheless, some research found no correlation between school size and academic performance (Jones & Ezeife, 2011; Gershenson & Langbein, 2015).

Academic attainment varies little between large and small schools, according to additional research (Ramirez, 1992; Cotton, 1996). According to Slate and Jones (2005), most data suggests that academic achievement is higher in small schools, but there is sufficient evidence in favour of large schools to imply that mediating variables play a role in the relationship between school size and accomplishment.

Several other characteristics associated, directly or indirectly, to school effectiveness and accomplishment may be influenced by school size. Several of these factors, including dropout rates, teacher quality, discipline concerns, teacher and student morale, student participation in extracurricular, daily school attendance, and parental involvement, have been studied (Slate & Jones, 2005). The association between school size and academic performance is proven to be indirect through a range of other variables, as revealed by the current review. Consequently, the link between school size and other school size indexes is likely to be complex. Unfortunately, there is currently a scarcity of studies addressing these complex interactions (Slate & Jones, 2005). This study aims to contribute to the literature review in order to gain a better understanding of this complicated phenomenon (school size) and its association with student achievement.

Class size

The shift from elite to mass higher education has likely increased economic strain in a few nations. In Ghana, for instance, the free compulsory basic education policy, the school food programme policy, and the present free senior high school policy, as noted in the school size review, have increased student enrolment in several schools. This has implications for class sizes in certain schools. Thus, the size of these classes will correspondingly increase.

Consequently, the significance of class size in relation to student progress and quality assurance has become such an important topic. Based on the above discussions, the variable was selected for examination in terms of its influence on students' math achievement. According to Chen (2013), class size is a factor extensively studied in relation to student achievement. It is widely accepted that a small class size is advantageous for the academic attainment of all students.

Earlier study has suggested that with smaller classrooms, possible management and discipline concerns can be resolved in a shorter amount of time, allowing for more time to be focused on teaching and learning activities (Blatchford, Russell, Bassett, & Martin, 2007; Konstantopoulos & Sun, 2014). However, scientific discoveries are exhaustive (Baker & Jones, 2005). While some research suggest that bigger class size has a negative influence on student achievement (Bandiera, Larcinese, & Rasul, 2010; Kogl, Camfield, McFall & Kirkwood, 2016; Kokkelenberg, Dillon & Christy, 2006; Westerlund, 2008), many others demonstrate positive effects (Nyatsikor, 2019; Butakor, 2015; Akyuz & Berberoglu, 2010; Pong & Pallas, 2001; De Paola et al., 2013; Edgell, 1981; Gleason, 2012; Hancock, 1996; Hill, 1998; Matta, Guzman, Stockly, & Widner, 2015; Olson, Cooper, & Lougheed, 2011).

Despite these findings, empirical research consistently supports the notion that both students and teachers perceive an enhanced learning environment when class size is reduced. Mullis et al. (2016) highlighted that despite a lack of consistent research findings linking class size reductions to increased student accomplishment, smaller classrooms are usually thought to be more controllable for teachers. Smaller class sizes result in students learning more (Benton & Pallett, 2013; Monks & Schmidt, 2011), being more involved (Gleason, 2012), and having a better attitude toward discipline (Edgell, 1981).

Summary of the Literature Review

Multiple factors at various levels relate to the mathematical achievement of students, according to the findings of this review. Nonetheless, conclusions on the relationships are still unclear, contingent on the research context and the type of variables analysed. Despite the research environment, nation characteristics, and the number of variables employed in the analysis, certain variables or determinants have proven to be robust in predicting mathematics achievement. Across multiple research contexts, methodologies to analysis, and sets of variables included in the study, school atmosphere has consistently been found to predict mathematical achievement (Ersan & Rodriguez, 2020; Mullis et al., 2020).

Culture may also play a role in predicting students' mathematical performance, according to the review. TIMSS-leading East Asian nations, such as Japan, Chinese Taipei, Korea, and Hong Kong, place a premium on student academic achievement (Ker, 2016). The cultures of these East Asian nations, as well as the teachers, place a strong emphasis on the academic achievement of students.

Given the literature's contradictory findings on the association between students' math performance and contextual factors, as well as the fact that only two research studies have been conducted in Ghana using TIMSS data, this current study is designed to further investigate the contribution of students and other contextual variables to students' mathematics achievement in different education systems or contexts. Using 2011 TIMSS data from Singapore and Ghana, specifically, to look at how both student and classroom/school-level variables contributes to the math achievement of grade 8 students.

CHAPTER THREE

RESEARCH METHODS

Overview

The main intent of this thesis was to make a comparison between Ghana and Singapore eighth grade students in terms of their math achievement using TIMSS 2011 with the view of learning from the Singaporean education system, which facilitates high mathematics achievement. The study specifically focused on which of the two levels (student and classroom/school) of the school system significantly influences the learning of mathematics in the two countries. The study also looked at which of the student-level factors and classroom/school-level contextual factors measured in the TIMSS 2011 were the best or strongest predictors of the math achievement of grade 8 students in the two countries. This chapter discusses how data was sourced and analysed to gain insight into the Ghanaian and Singaporean education systems. In this chapter, the following methodologies and procedures were considered: research design, the study's philosophical position, TIMSS, data source, population, sampling procedure, instrument, and data collection procedures. Secondly, processing and analysis of data, which includes TIMSS data cleaning and entry procedures, missing data management, justification of the selection of variables for the study, HLM assumption issues such as weighting, cantering, multicollinearity, outliers, and various HLM equations connected with the different levels of analysis.

Research Design

Literature indicates that research design is the general goals, strategies, and processes for research that range from broad assumptions to the specific approaches to data collecting and analysis; it is the plan for how data will be collected, measured, and analysed. (Creswell, 2009; Cohen, Manion & Morrison, 2018). The study design provides an overarching framework for the researcher's methodologies, collection and analysis of data. A research design is a strategy for conducting a research investigation. There is no single "correct" approach to conduct research, but there are multiple traditions, each of which tends to follow its own, internally consistent set of decisions.

The development of a research design begins by situating the planned task within a research paradigm. It is important to highlight that these inferred paths for conducting research are not fixed, even though particular data gathering and analysis techniques tend to adhere to certain paradigms. What is genuinely essential is the researchers' capacity to recognise and defend the interconnecting decisions that constitute their own research design. Thus, the choice of a particular research design for a study is contingent upon the research paradigm. The above statement makes it imperative to understand what research paradigms are and the types that might lead to the selection of a research design for a specific research problem.

Different Types of Research Paradigms

Theoretical perspectives (paradigms) are essential components of study methodology that direct the study's progress (Crotty, 2020). A paradigm is a shared worldview that embodies the beliefs and values of a discipline and guides problem-solving in that discipline (Schwandt, 2001; Cohen, et al., 2018). It is a fundamental set of beliefs that impact behaviour (Guba, 1990: Mertens, 2010). According to Harré (1987), a paradigm is a mix of a philosophical theory about the nature of objects in a particular field of study and a custom-tailored method for acquiring information about those objects. In other words, a paradigm is a set of assumptions and perceptual orientations shared by all researchers. Research paradigms define how members of research communities view the phenomena they examine as well as the research processes that should be used to investigate such phenomena. Others have referred to them as paradigms, epistemologies (means of understanding reality), and ontologies (our views about the nature of reality) (Crotty, 2020) or, more generally, research approaches (Neuman, 2000).

Hughes and Sharrock (2016) argue that every research methodology is intrinsically entwined with commitments to a specific worldview. There are essentially three types of research paradigms that can be used to conduct a research endeavour. Quantitative, qualitative, and mixed techniques are included. The theory underlying quantitative research paradigms is that only a positivist paradigm can adequately explain all that happens in the world. They argue that a phenomenon can only have one reality and explanation that can be uncovered using scientific and quantitative approaches. They argue that any study should be generalizable to a degree to similar contexts. Quantitative research quantifies variables and employs numerical evaluation to address problems. Constructivism's problem-solving methodology dominated the qualitative research paradigm. According to constructivists, there is a significant distinction between qualitative and quantitative research. Neither type of inquiry can be resolved with a single paradigm. Prior to the emergence of the pragmatic paradigm, it was believed that qualitative and quantitative research could not be merged. The pragmatic methodology integrates quantitative and qualitative methodologies. This mixed-methods approach facilitates the comprehension of otherwise qualitative-only research. Constructivists believe that reality is formed depending on experiences, conditions, and events. Since reality is multifaceted, it is difficult to predict if the same outcome will occur in another identical situation. These three paradigms logically and basically drive the type of research design to be adopted to solve a research problem. The three basic categories of research designs: quantitative, qualitative, and mixed methods emanated from these research paradigms.

It is important to distinguish between causal comparative study designs, which are also known as ex post facto, and comparative research designs, since the word "comparative" features in both designs. A causal-comparative design is a quantitative research design that investigates the links between independent and dependent variables following the occurrence of an action or event. According to Cohen et al. (2018), "ex post factor" in the context of social science and educational research means "after the fact" or "retrospectively" and refers to studies that investigate possible cause-and-effect relationships by observing an existing condition or situation and searching backward for plausible causal factors. Ex post facto research or causal comparative study is a strategy for identifying plausible causes of events that have already occurred and therefore cannot be controlled or influenced by the researcher (Cohen et al., 2018). By comparing two or more groups of individuals, the researcher attempts to determine whether the independent variable or the dependent variable influenced the outcome.

The design is appropriate when the more powerful experimental method cannot be utilised. These arise when, for example, it is not possible to choose, control, and modify the variables essential to examine cause-and-effect correlations directly; or when it is unrealistic to control all variables save for a single input variable (Cohen et al., 2018). In social, educational, and (to a lesser extent) psychological settings when the researcher lacks control over the input variable or factors, ex-post-facto research are effective.

Comparative research, on the other hand, is a research methodology that compares nations, civilizations, societies, and organisations. Regarding the terminology, scholarly usage varies. Others want to broaden the scope to encompass comparisons of numerous social and/or cultural phenomena (Sasaki, 2012). Nonetheless, some academics employ the phrase to compare socioeconomic substructures inside or between nations.

The above discourse on the use of the term "comparative research" indicates that scholars are far from agreement on a definition of comparative research. Despite the different uses of the term comparative research, the trend of discourse appears to be towards defining comparative research as a research methodology that systematically compares two or more societies, cultures, or nations (Sasaki, 2012). Strictly speaking, to "compare" is to study two or more entities by juxtaposing them and looking for similarities and contrasts. Simply described, comparative research is the process of comparing two or more items in order to learn something about one or all the objects being compared. In terms of the implementation of comparative research, comparisons of nations or countries dominate in practice.

Comparative research design as a general research methodology can be categorised depending on the field that adopts the design in its investigation. Many fields and disciplines (e.g., social science, law, psychology, and education) use or adopt this research design in their quest to compare societies, cultures, legal systems, institutions, and educational systems. For instance, if the comparative research design is employed to compare educational systems in two or more nations, the design is categorized as comparative educational research. Similarly, if the design is engaged to investigate the differences and similarities between or amongst two or more legal systems, the design is categorized as comparative law research or comparative research in law. Also, if the comparative research design is adopted to make comparisons between different cultures, the design falls under comparative social science research.

Since this current study compares the educational systems of Ghana and Singapore, the adopted research design falls under comparative education research. Comparative educational research is a field in the social sciences that examines and evaluates diverse educational systems, such as those in different nations (e.g., Ghana and Singapore), as in the case of this current study (Bray & Thomas, 1995). Getao (1996) defined comparative education as a discipline, the study of educational systems in which one seeks to understand the similarities and differences among educational systems. Throughout the last 50 years, comparative education theorists have sought to define and redefine the discipline, as well as speculate on its future viability

(Wolhuter et al., 2011). Considering the definitions of these experts as indicated above, one theme emerges; the study of educational systems. Based on the theme gleaned from the various definitions by experts, I define comparative education as a scientific procedure of investigating two or more educational systems with the view of learning from the more effective education systems. The more effective educational system might be conceptualised as a system that produces students with high academic achievement (e.g., mathematics achievement).

Comparative education research, like any other study approach, seeks to find similarities and differences between social units. The objective of comparative research is to compare countries, cultures, civilizations, and organisations. Comparative studies can be used to enhance mutual comprehension between cultures, civilizations, and educational systems and to lay the groundwork for compromise and cooperation. These studies employ both quantitative and qualitative approaches of inquiry. In the sphere of education, this concept can be applied both to comparisons across and within educational systems. There are a range of approaches for conducting comparative research, ranging from purely qualitative to purely quantitative. The descriptive qualitative technique is exemplified by case studies and comparable analyses, which can be undertaken by researchers who are members of the social entities being studied or by researchers from outside the social entities being analysed. In recent years, quantitative approaches to comparative study have grown in popularity as tools (notably computational, statistical, and mathematical ones) to address the numerous methodological obstacles of rigorous comparative research have become available.

A significant challenge in comparative research is that data sets from various nations may define categories differently (for instance, by employing different poverty definitions) or may not use the same categories.

The following reasons justify the selection and adoption of this research design: To begin, the TIMSS 2011 data used in this study as secondary data were collected quantitatively using a quantitative research design. Since TIMSS studies are predominantly quantitative, it was considered most appropriate to adopt a quantitative approach to analyse its data. Secondly, purpose of the study also influenced the adoption of quantitative approaches to its investigation (Pallant, 2020; Johnson & Christensen, 2016; Cohen et. al., 2018).

Stressing the importance of quantitative methods in research, Stangor (2011) postulates that if one can understand why things are connected to each other and why certain consistent patterns occur, then, one may make better predictions and inferences than if one simply observes and remembers those patterns. Quantitative researchers believe that to ensure the reliability of these findings, as many "subjective" elements as possible must be eliminated from the study process. One method to accomplish this is to adhere to clear, standardised practises that others can replicate (Nyatsikor, 2019). The primary advantage of quantitative techniques is that conclusions can be generalised to broader populations when the data are based on sufficiently large random samples, as in this study (Muijs, 2011; Bryman, 2012). Generalisation of findings over a given population would not have been feasible with a qualitative approach (Creswell, 2014; Gray, 2014). Advocates of this approach to research also stress that it has more credibility with administrators, policymakers, and politicians who generally are interested in making decisions to cover large constituencies (Johnson & Onwuegbuzie, 2004).

Despite the value attached to the use of quantitative data, critics have highlighted its selective use by politicians and interested stakeholders (Nyatsikor, 2019). One of the criticisms raised by the critics of quantitative research is the subjectivity in designing and interpreting quantitative research. Connolly (2007) noted that several subjective judgements are made in the development, measurement, and interpretation of quantitative research, thus rendering a quantitative approach not entirely "objective." Crossley (2014) has argued that quantitative research studies do not provide sufficient context-sensitive data to raise educational standards, particularly in low-income nations with diverse cultural histories.

The Study's Philosophical Position

Hughes and Sharrock (2016) argue that every research methodology is intrinsically entwined with commitments to a specific worldview. This study's philosophical position is anchored in the post-positivist paradigm (a variation of its predecessor, positivism). All true knowledge must be based on science, according to positivism. Positivism maintains that all truth is verifiable and demonstrable scientifically, as well as measurable and observable (Johnson & Christensen, 2016). This position discredits religious revelation as a source of knowledge since it cannot be scientifically demonstrated or refuted. Positivism is developed from realism in the sense that there exists an external world that must be investigated. Positivism is the foundation of quantitative research for academics. Quantitative researchers strive for objectivity in their investigations. They attempt to avoid encountering whatever they are studying so as not to upset the environment. One of the key objectives is to generalise what applies to all situations.

Post-positivism is an approach to social science study that use the research paradigm of the physical sciences to investigate and explain the social environment (Hammersley, 2012; Mertens, 2019). Post-positivists believe in the significance of objectivity and generalizability, but also advocate those researchers change their "truth" assertions to be based on probability rather than certainty (Mertens, 2019; Denscombe, 2007). In contrast, post-positivists attempt to reflect reality as accurately as possible, rather than searching for "truth" (Hammersley, 2012; Johnson & Onwuegbuzie, 2004). Thus, post-positivism focuses on levels of confidence by posing questions such as, to what extent can our findings be relied upon? How accurately do they forecast outcomes? The researcher believes that quantitative methodologies can be used to "quantify" how students, classrooms, and institutions influence the learning outcomes of students.

Some researchers have highlighted concerns regarding the methods post-positivists employ in their pursuit of knowledge. For example, Hammersley (2012) argues that post-positivism fails to account for the special nature of human social existence, which necessitates a different methodology in order to comprehend what people do and speak. As an approach, post-positivism fails to recognise the role of the researcher in generating the phenomena depicted in data and findings, as well as the importance of narrative and language in research reports. As a restriction, post-positivists recognise that we cannot watch the world as objective, disinterested outsiders and that the natural sciences are not the paradigm for explaining all social studies (Cohen et al., 2018; Bryman, 2012; Hammersley, 2012). Another issue with post-positivism is that it advocates treating people primarily in terms of numbers or groups, which makes people, feel uncomfortable (Hammersley, 2012).

Data Source

The methods used to gather, combine, and create a viable dataset for the analysis of the current study is described in this section. On the IEA website (http://www.timss.org), the TIMSS data are freely downloadable in raw format. Hence, TIMSS 2011 eight grade raw data and other materials were downloaded. The information in data and other materials includes variables from the TIMSS 2011 that were collected about students, teachers, and school setting. The data also provided mathematical achievement scores, weighting variables, and scores in the form of five plausible values. Almanacs, codebooks, test questions, program reports, and user manuals are among the available documents.

The raw datasets were in both SAS and SPSS formats. Additional supporting documents were available in Excel and PDF formats. Since the data of all 2011 participating countries were downloaded as one shot dataset, I used the IDB analyser to sample or extract Ghana and Singapore dataset from the entire 2011 TIMSS dataset to meet the purpose of the study. The IEA's IDB analyser is a standalone application that generates syntax in SAS and SPSS that can be used to analyse large-scale assessment databases such as those published by the IEA (TIMSSS and PIRLS etc). The teacher and school data sets from Ghana and Singapore needed to be combined. Therefore, the data were merged using the IDB tool to prevent any mistakes that could have happened if a manual merge had been attempted. By using the tool, one may be sure that the data has been combined with all the appropriate variables, weights, and realistic values as intended by the IEA. Both a comprehensive dataset that included all students, teachers and schools in the eighth grade and a large dataset that combined the data from the two countries were created using the IDB. The output SPSS syntax files of the datasets were then used as input files for the final HLM analysis.

Population

TIMSS identified two types of populations of students for their study, namely, target (international population and national population). Each population was made up of students in the fourth grade (equivalent to Class 4 in Ghana and Primary 4 in Singapore) and eighth grade (equivalent to Junior Secondary School Form Two in Ghana and Secondary two in Singapore) in the subjects of math and science. Unlike Singapore, which participated in TIMSS in both the 4th and the 8th grades, Ghana only participated in TIMSS in the 8th grade. Since this current study focused only on the 8th grade math performance of Ghanaian and Singaporean students in TIMSS 2011, all Ghanaian and Singaporean students enrolled in the 8th grade of formal schooling with their mean ages of 15.8 and 14.4 respectively at the time of testing were used. The population sizes of 8th grade students in TIMSS 2011 were made up of 424,132 Ghanaian students (3501 females and 3822 males) nested within 9,166 schools and 50205 Singaporean students (2250 females and 3677 males) nested within 165 schools.

Sampling Procedures

A two-stage stratified cluster sampling design was used by TIMSS to make sure that the students who took part in each country were reflective of the population (Chepete, 2008). In the first stage, a systematic probability proportional to size (PPS) sample was taken from the sampling frame of grade eight schools in the nation (Martin et al., 2012; Mullis & Martin, 2017). In other words, schools were selected based on likelihood proportional to their size, using a sampling method in which larger schools were selected with a greater probability (Brewer & Hanif, 1983). The sampling process involved selecting schools from a list (the school's sampling frame) that was stratified based on the demographic variables such as school performance on national examinations, socio-economic indicators, urbanicity (rural, semi-urban, or urban), school type (private or public), and jurisdiction of the country (states or provinces). In TIMSS, stratification was used to: (a) make the sample design more efficient, thereby increasing the accuracy of the survey estimates; (b) give different sample designs, such as unequal sample allocations, to certain groups of schools (such as those in certain states or provinces); and (c) ensure that certain groups of schools were proportionally represented in the sample (Martin et al., 2012).

In the second stage, random selections were made of one or two complete classrooms per school (Martin et al., 2012; Martin & Mullis, 2017). Because TIMSS pays particular attention to students' curricular and instructional experiences, which are often organised on a class-by-class basis, whole classes of students were sampled rather than individuals from across the grade level. Individual student sampling is more disruptive to the school's daily operations than sampling entire classes. TIMSS employed a technique known as systematic random sampling to select one or two entire classrooms from each of the examined schools.

Because many Ghanaian schools only had one class every year, only one whole eighth-grade classroom was chosen from all the eighth-grade classrooms in the sampled schools (Ghagar et al., 2011). The average number of students per classroom ranged from 19 to 49, with 35 being the most common. The entire sample size for the TIMSS 2011 study included 7323 students, 161 math teachers, and 161 school principals from Ghana. Singapore introduced an additional sampling stage to the TIMSS's stage two, with students randomly selected from two classrooms in each school. Because some Singaporean schools have more than one eighth-grade classroom. The lowest number of students per classroom was eight, the highest was twenty-three, and the average was eighteen (Ghagar et al., 2011). In Singapore, samples included 5927 students, 380 math teachers, and 165 school principals who took part in the TIMSS 2011. Following that, each of the students in the sample was given a background questionnaire and a subset of cognitive tasks.

Given these techniques of selection, it should be evident that LSA studies do not employ a basic random sample strategy in which every student in the target population is chosen with equal chance. This also implies that a student whose school was not selected had no chance of being chosen (Ghagar et al., 2011)

Instruments for Data Collection

The 2011 TIMSS relied on two key data collection tools: (a) achievement tests and background surveys. TIMSS is made up of four achievement tests: two math tests and two science tests in eighth grade and fourth grade. Each of the two tests for fourth grade has about 170 questions, and each of the two tests for eighth grade has about 200 questions (Martin et al., 2012). Also, since the main goal of TIMSS is to find ways to improve education, the tests collect a lot of descriptive information about how teaching and learning happen in the countries that take part. As a result, TIMSS includes sets of questionnaires for fourth and eighth grade students, as well as their mathematics and science teachers and school principals (Martin et al., 2012). Because the goal of this study was to find out what made Ghanaian and Singaporean eighth-graders excel at math in TIMSS 2011, it was necessary to describe how the eighth-grade mathematics achievement test, eighth-grade mathematics teacher questionnaire, school background questionnaire, and eighth-grade student background questionnaire were created (Martin et al., 2012).

Mathematics Achievement Instrument

In TIMSS 2011, eighth-grade students took a TIMSS-created mathematics achievement test to collect data on their math achievement. In this session, an attempt will be made to describe the mathematical achievement test. The eighth grade TIMSS mathematics achievement test consisted of achievement booklets including two portions, and the test administrators standardised and rigidly enforced the time given to each section (Martin et al., 2012). Constructed response types and multiple-choice were the two main categories of items or questions. The choice between these two forms hinged on the subject (mathematics), the optimal approach for students to demonstrate their mastery of the material, and the dependability with which the exam could be administered and scored (Martin et al., 2012).

In the 2011 TIMSS mathematics test items, four curriculum categories were addressed: data and chance, geometry, algebra, and number. The content domains for data and chance consist of data organisation and representation, data interpretation, and chance (probability) (Martin et al., 2012). The subject domain for geometry included geometric shapes, geometric measurement, and position and motion. Algebra's primary subject areas included patterns, algebraic expressions, equations, formulas, and functions. The content domain included skills and knowledge pertaining to whole numbers, fractions and decimals, integers, and ratios, proportions, and percentages (Butakor, 2015; Martin & Mullis, 2012; Martin & Mullis, 2017).

The TIMSS assessment framework is designed such that 20% to data and chance, 20% to geometry, 30% to algebra, and 30% of the test questions pertain to the number content area (Butakor, 2015). The TIMSS mathematics assessment items were also developed to measure many cognitive levels, including knowing, applying, and reasoning (Butakor, 2015). Regarding cognitive regions, 25% assessed thinking, 40% assessed application, and 35% of the items assessed knowledge (Mullis et al., 2012).

The TIMSS 2011 mathematics test comprised 2007-released questions, 2007- and 2011-recurring questions that were not disclosed and 2011-exclusive questions. This is because TIMSS achievement instruments for a given testing year are designed to include items from the previous testing cycle, items shared by the previous and current cycles but never incorporated in the present cycle, and latest items (Butakor, 2015). The inclusion of previously available and previously unreleased items, according to Mullis et al. (2012), allows for a credible assessment of developments in math learning and instruction across time. The usage of common components permits the 2007 and 2011 assessments to be linked. The 2011 eighth-grade TIMSS mathematics test contained 303 questions.

Because of the large amount of math exam tasks, TIMSS uses a matrix sampling approach in which each student receives a subset of the items. In this system, each item is assigned to one of 14 distinct item blocks. Student test booklets are then constructed utilising various item block pairings to ensure subject-matter coverage (Butakor, 2015). Each item block in eighth grade comprises 12 to 18 items (Butakor, 2015). In terms of 2011 assessments, eight of the fourteen item blocks contained secure items from the 2007 assessment in order to measure change between 2007 and 2011, while the remaining six blocks featured new items for 2011 (Butakor, 2015). Each item block includes both multiple-choice and open-ended questions. Each item block has 8 to 9 multiple-choice questions (1 point), 3 to 4 short-answer constructed-response questions (1 point), and 1 to 2 extended-response questions (1 point) (1 or 2 points). The fourteen maths blocks are spread over 12 randomly chosen student booklets (Butakor, 2015; Mullis et al., 2009). Tables 4, 5, and 6 show the TIMSS 2011 math test broken down by item type, content domains, and cognitive domains.

Table 4: TIMSS 2011 Mathematics Test Item Types

Item Type	Points	Items released in 2007	Items common in 2007 and 2011	Items introduced in 2011	Total
Multiple-choice	**1**	50	66	52	168
Constructed response	**1**	27	45	37	109
		11	13	2	26
Constructed response	**2**	88	124	91	303
Total		50	66	52	168

Source: Butakor (2015)

Table 5: TIMSS 2011 Mathematics Test Item by Content Domain

Content Domain	Items released in 2007	Items common in 2007 and 2011	Items introduced in 2011	Total
Number	32	30	31	93
Algebra	17	46	23	86
Geometry	22	24	18	64
Data and chance	17	24	19	60
Total	88	124	91	303

Source: Butakor (2015)

There are four possible options to each multiple-choice question on the TIMSS, but only one is right. These questions can be used to judge how someone acts or behaves in any of the cognitive domains. Multiple-choice questions let you test a wide range of content in a short amount of time in a valid, reliable, and cost-effective way.

Table 6: TIMSS 2011 Mathematics Items by Cognitive Domains

Cognitive Domains	Items released in 2007	Items common in 2007 and 2011	Items introduced in 2011	Total
Knowing	28	52	27	107
Applying	45	42	42	129
Reasoning	15	30	22	67
Total	88	124	91	303

Source: TIMSS (2011)

Because they lack in clarifications and additional remarks from students, multiple-test items are less appropriate for measuring students' abilities to construct more sophisticated interpretations or judgments. It is critical that the language qualities of the questions be developmentally appropriate when evaluating eighth-grade students. As a result, the questions were written in a clear and succinct manner. To lessen the question's reading load, the response possibilities were also given concisely. The incorrect selections were meant to be realistic but not deceptive. For students who were new with this exam question style, the test instructions featured a template multiple-choice item that illustrated how to choose and indicate an answer (Mullis et al., 2009).

As previously indicated, the mathematics achievement exam booklet or instrument comprised numerous items that were followed by a built response. For this type of exam item, students must write a response rather than choosing from a list of answers. Constructed-response questions are especially well-suited for assessing knowledge and abilities that require students to explain events or interpret facts based on previous experiences and knowledge. Tables 8 and 9 provide the number of items (and score points) for each content and cognitive domain.

Field or Pilot Testing of Test Items

To provide sufficient high-quality items for the TIMSS 2011 mathematics assessments, an ambitious field test was conducted in March and April 2010. TIMSS field-tested roughly twice as many items as were required for final test item production. At each grade level (e.g., eighth), TIMSS removed six of the 14 blocks previously assessed (in TIMSS 2007), and these six blocks must be replaced. Thus, $6 \times 2 = 12$ blocks of items per grade and subject were field tested. Specifically, the eighth-grade mathematics field test consisted of 12 blocks comprising around 170 items in total (Mullis et al., 2009). Table 9 provides a comprehensive account of the field test effort, including the number of participating students, teachers, and schools. The number of items listed by format, content domain, and cognitive domain is presented in Tables 7 and 8. TIMSS 2011 employed over 10,000 student responses from over 40 nations per grade to determine the quality of each field test assessment item (Mullis et al., 2009).

Table 7: Overview of TIMSS 2011 Field Test

Items	Fourth grade	Eighth grade
Mathematics	143	178
Science	139	176
Total	**282**	**345**
Responses per item (approximately)	10,000	10,000
Participants		
Countries	48	44
Students	63,901	60376
Teachers	2924	6826
Schools	1761	134

Source: TIMSS (2011)

Table 8: Eighth Grade TIMSS 2011 Number of Field Test Items by Content Domain and Item Format

Content Domain	Number of Multiple-Choice Items	Number of Constructed-Response Items 1Point	2 Points	Total Number of Items	Total Number of Score Points	Percentage of Score Points
Mathematics items						
Number	32	26	2	60	62	33%
Algebra	23	18	6	47	53	28%
Geometry	14	20	1	35	36	19%
Data and Chance	19	15	2	36	38	20%
Total	**88**	**79**	**11**	**178**	**189**	**100**

Source: Butakor (2015)

Table 9: Eighth Grade TIMSS 2011 Number of Field Test Items by Cognitive Domain and Item Format

Cognitive Domain	Number of Multiple-Choice Items	Number of Constructed-Response Items 1Point	2 Points	Total Number of Items	Total Number of Score Points	Percentage of Score Points
Mathematics Items						
Knowing	43	12	1	56	57	30%
Applying	33	40	7	80	87	46%
Reasoning	12	27	3	42	45	24%
Total	**88**	**79**	**11**	**178**	**189**	**100**

Source: Butakor (2015)

Following the field test, the TIMSS International Study Centre finalised the TIMSS 2011 Achievement Items by analysing the TIMSS field test data and preparing manuals with summary item statistics for each field test item (Martin et al., 2012). The data manual for an item contained, column by column, the sample size, item difficulty and discrimination, the percentage of students answering each option (multiple-choice) or in each score category (constructed response), the point-biserial correlation for each multiple-choice option or constructed response category, and the degree of scoring agreement for constructed response items for each country (Mullis et al., 2009). The International Study Centre, expert committees, and NRCs used the field test data to evaluate how good the field test items were. Initial evaluation of the quality of each item was based on the measurement parameters of the field test data (item statistics). If an item had poor measuring features, such as being too easy or difficult too or having low discrimination, it was excluded from further evaluation. There was a heightened focus on anomalous item data in individual nations, as these could suggest translation mistakes.

Background Questionnaire

TIMSS collects data on background and contextual elements that influence students' mathematics learning because learning does not occur in isolation. The questionnaires concentrate on background and contextual aspects identified in the research as critical for improving students' maths achievement. These aspects include school type, parental learning support, teacher characteristics, instructional approaches, school resources, learning opportunities, student, and attitudes, (Mullis & Martin, 2017; Mullis et al., 2009). The national curriculum questionnaire, the student questionnaire, the questionnaire for mathematics teachers, and the school questionnaire were all part of the TIMSS 2011 contextual framework. The eighth-grade mathematics surveys included 18 multiple-choice questions relating to background characteristics of students, perceptions of the school environment, attitudes toward mathematics, experience with mathematics and science, and household possessions. Certain questionnaire items are modified to reflect the country's national context due to cultural and socioeconomic differences (Mullis et al., 2009). For example, questions about the parents' education and household items are either adjusted or omitted to reflect the country's culture (Butakor, 2015).

The questionnaire for mathematics teacher comprises 28 multiple-choice items designed to elicit information relating to teaching experience, teachers' educational credentials, licensure, curriculum in use, pedagogical and instructional activities, and professional development (Butakor, 2015). Some questions, as in the student survey, are amended or eliminated to cater for different national settings (Mullis et al., 2009; Mullis & Martin, 2017).

The school questionnaire includes questions for the principal or headmaster on the school's atmosphere, the school's location, the national curriculum, teaching and learning resources, and essential details regarding the environment in which math is delivered and learnt (Butakor, 2015). As with prior questionnaires, such as the TIMSS 2007 school questionnaire (Butakor, 2015; Mullis et al., 2009; Mullis & Martin, 2017), some elements are adjusted or eliminated to accommodate diverse national contexts.

A Field Test of Background Questions

To guarantee enough high-quality items for the TIMSS 2011 background questionnaires, there was an equally ambitious field test during March–April 2010. Using the field test data, the measurement properties of each of the items intended to form a background scale were analysed to guarantee that the items would be suitable for scaling with the 1-Parameter IRT (Rasch) measurement model after the 2011 data collection. This entailed verifying the assumption of an underlying unidimensional construct and assessing the validity of the generated scale. As meaningful markers of successful learning settings, the background measures must be correlated with student accomplishment. Consequently, the correlation between item sets and student mathematical achievement was also explored (Mullis et al., 2009; Mullis et al., 2017).

Context Questionnaire Scale Dimensionality

According to research specialists, there is no absolute criterion for a set of items to constitute a unidimensional scale; nonetheless, a scale is often deemed "sufficiently unidimensional" if a single underlying construct exerts a preponderant influence on the item responses (Reckase, Ackerman, & Carlson, 1988; Embretson & Yang, 2006). In the terminology of factor analysis, this indicates that a single large factor accounts for most of the correlation between the components (Mullis et al., 2009; Mullis et al., 2017). Principal Components Analysis was used to evaluate the dimensionality of the items for each scale on the TIMSS 2011 field exam. For these analyses, field test data from all participants was merged. In the analysis, all nations were treated identically, regardless of sample size. To examine the validity of a unidimensional underlying construct, a first principal component analysis was done (Mullis et al., 2009; Mullis et al., 2017). If many components were indicated, the item set was altered to better adhere to a single dimension. Thus, items that did not load on the first component were marked for removal from the scales. In accordance with Comrey and Lee's (1992) rule of thumb, items with factor loadings (correlations between each item and the entire scale) of less than 0.3 were removed from a scale unless they were deemed crucial for measuring the concept. The item sets for most scales were deemed to be suitably unidimensional, despite the identification of a few items that did not contribute to the assessment of the construct (Mullis et al., 2009; Mullis et al., 2017). These items were rejected.

Estimating the Reliability of the Context Questionnaire Scale

Reliability is one of the most important metrics for evaluating data quality. The degree to which a measurement or calculation may be regarded accurate constitutes reliability. Unlike validity, where evaluations are based on the acquisition of data, reliability necessitates the use of several metrics to assure research analysts, policymakers, and other ILSA stakeholders that the assessment remains trustworthy throughout the many stages of the study.

Cronbach's alpha, a measure of internal consistency, was calculated for each contextual scale to provide an indication of their dependability. A scale was deemed credible if it’s Cronbach's Alpha was at least 0.70. (Nunally & Bernstein, 1994; Taber, 2018). Most proposed scales had Cronbach's Alpha coefficients above 0.70. However, a few components were identified that did not improve the dependability of the scale and were therefore recommended for removal (Mullis et al., 2009; Mullis et al., 2017).

Validity of the Context Questionnaire Scale

In test development and psychometric testing, validity is an essential notion. In general, validity is the extent to which empirical data and theoretical rationales support the adequacy and appropriateness of judgments reached from some form of assessment (American Psychological Association (APA), 2021). TIMSS 2011 also utilised item analysis to establish construct validity (Foy & LaRoche, 2016).

TIMSS Data Collection Procedures

The data collection stage in any research study is vital to the outcomes and findings of the research. This is because quality data collection procedures will produce corresponding quality data, which will eventually yield dependable research findings if analysed with the right statistical methods. As data-based indicators of student performance profiles and learning environments, TIMSS assessments rely heavily on the quality of the data collected by each participant (country) (Martin, Mullis & Hooper, 2016; Mullis et al., 2009; Mullis et al., 2017).

This section contains information about the data collection procedures used to acquire TIMSS data in 2011. All participants (states) were expected to follow a specified set of operating standards in order to ensure the homogeneity of procedure essential for high-quality, globally comparative data (Martin et al., 2012). As noted previously, the TIMSS 2011 data used in this study were acquired using achievement exams and demographic questionnaires (for example, teacher questionnaires, student questionnaires, and school questionnaires). The key operational activities coordinated by the TIMSS National Research Coordinators (NRC) are as follows:

1. Contacting schools and sampling classes
2. Overseeing translation and preparing assessment instruments
3. Managing the administration of the TIMSS 2011 assessments

In collaboration with school principals, NRCs oversaw identifying and training school coordinators for all participating schools. A School Coordinator may be guidance counsellor or a teacher in the school, or an NRC member may be assigned to this post (Martin et al., 2012). The school coordinators were responsible for providing information about the school to the national centre, coordinating the testing location, time, and date, identifying, and training a test administrator to administer the assessment, coordinating the completion of the TIMSS 2011, and distributing questionnaires, tracking forms, and obtaining parental permission (if necessary). School coordinators also played an important role in data collection for the sampling process by providing information on eligible courses in the school to the national centre (Martin et al., 2016; Mullis et al., 2009; Mullis et al., 2017).

One of the school coordinator's responsibilities as intact classrooms were sampled was to ensure that every student in the school was listed in exactly one class. This was necessary to ensure that the classroom selection produced a representative sample of students and that every student in the target grade had a chance of being chosen. Furthermore, the NRCs oversaw developing assessment tools (achievement booklets and questionnaires) for their countries. The fundamental goal of developing evaluation tools was to construct achievement booklets and background questions that could be used globally while also being personalised to each country.

For the field test, all participating nations translated and/or modified the newly created assessment blocks and background questionnaires into their original language (s). Following the field test, the best replacement blocks for primary data collection were chosen, and the questions and background questionnaires were revised. The global edition (English) of the performance booklets and background questionnaires, including the necessary instrument production resources, including as fonts and visual files, were distributed to the participating nations (Martin et al., 2012). Instructions for using the components to create standardised high-quality instruments were also made available (Martin et al., 2016; Mullis et al., 2009; Mullis et al., 2017). The NRCs used Adobe InDesign software to create the achievement booklets and background questionnaires, and print-ready copies of the booklets were given to the TIMSS & PIRLS International Study Centre for layout validation and a final review of national adaptations. All these steps were done to assure the TIMSS 2011 data's international applicability.

During the TIMSS assessment administration, each sampled class was assigned a Test Administrator who administered the achievement booklets and student surveys in accordance with the Test Administrator Manual. This individual was selected and educated by the school coordinator. The Test Administrator was responsible for distributing materials to the relevant students, given instructions from the Test Administrator's manual to the students, and timing the testing sessions. On the test administration form, the test administrator recorded the duration of each testing session. The Test Administration Form also requested information regarding anything odd that occurred during the administration of the exam.

The TIMSS achievement booklets comprised two components, and the Test Administrator standardised and carefully enforced the time permitted for each section of the assessment. Between the two phases of the examination administration, there was a 30-minute break that was required. Students in eighth grade were given 45 minutes to complete each section of the TIMSS achievement test. If a student completed part 1 or part 2 of the examination before the specified time, they were not permitted to leave the testing room. Students were allowed a minimum of half an hour to finish the student survey, with additional time allowed if necessary. According to Mullis et al. (2009), data were gathered in the Southern Hemisphere between December 2010 and March 2011 and in the Northern Hemisphere between June and September 2011. Since Ghana and Singapore are in the Southern Hemisphere, data collecting in these two nations began in December 2010 and continued through March 2011, a span of over three months. The TIMSS 2011 research did not indicate any significant difficulties in terms of data collection techniques.

Processing and Analysis of Data

This section outlines briefly the procedures taken by the IEA Data Processing and Research Centre (IEA DPC) for verifying the TIMSS 2011 data and generating the TIMSS 2011 International Database (IDB), since this thesis utilised TIMSS 2011 data for analysis. Preparing and ensuring the accuracy of the TIMSS 2011 International Database (IDB) was a challenging task that required extensive collaboration between the IEA Data Processing and Research Centre, the TIMSS & PIRLS International Study Centre, Statistics Canada, and the national centres of participating countries (Martin

Mullis & Hooper, 2016; Mullis et al., 2009; Mullis et al., 2017). As soon as the countries had prepared their data files and sent them to the IEA DPC, the "data cleansing" procedure commenced. Data cleansing is the process of examining data for inconsistencies and formatting it to achieve a standard output. TIMSS did so to satisfy the following expectations:

1. All database information adheres to the internationally recognised data structure.
2. All codebooks and documentation represented national adjustments of questionnaires in a suitable manner.
3. All factors employed in international comparisons were comparable across nations (after harmonization, as needed).
4. To ensure the quality and accuracy of the TIMSS 2011 assessment, all institutions involved implemented quality control methods throughout the process.

According to Mullis et al. (2009), the IEA DPC was responsible for examining the data files from each country (such as Ghana and Singapore), established data clean-up criteria are used to verify the data's authenticity and reliability, and any variations from the global file format are documented (Martin et al., 2012). Before forwarding them to the IEA DPC, each country's national centre compiled and validated data files.

Overview of the TIMSS 2011 Data Cleaning Process

Following a standard data cleansing procedure, the IEA Data Processing and Research Centre and the NRCs consulted regularly. After data collection and data entry, each country provided the IEA DPC with its data, codebooks, and documentation.

The cleaning procedure consisted of repeated steps. On each national data set, several loops of the four-step cleaning procedure were conducted. The repetition ensured that all the data was properly cleansed and that any additional errors generated during the data cleansing procedure were addressed (Martin et al., 2012). The cleaning process was repeated as many times as possible until all the data were uniform and comparable (Martin et al., 2012). Discrepancies discovered throughout the cleaning process were resolved in partnership with national centres. Each country's cleaning report included a record of all corrections made during the cleaning procedure (Martin et al., 2016; Mullis et al., 2009; Mullis et al., 2017).

Following the final clean up cycle, each country's data was given to Statistics Canada for sampling weight calculation, and the data, together with the sampling weights, was transferred to the TIMSS and PIRLS International Study Centre for scaling (Martin et al., 2016). At three distinct stages of the process, the NRCs were presented with interim data products for evaluation (Martin et al., 2016; Mullis et al., 2009; Mullis et al., 2017).

Data Entry Procedures

Overall, the national centres provided the IEA Data Processing and Research Centre with data files of good quality and consistency. Before submission to the IEA DPC, the data were initially entered and then reviewed by the national centres. The NRCs were supported throughout the process by operational procedures manuals, training sessions, and specialised software.

The national centres were backed by IEA Data Management Expert (DME) software, for instance. The DME is a software system created by the IEA DPC that enables data entry and incorporates validation tests to detect discrepancies and errors. The DME also ensured worldwide data input standards (Martin et al., 2016; Mullis et al., 2009; Mullis et al., 2017).

Data Screening

Data screening, also known as data inspection, is the process of ensuring that the obtained data for a study are error-free and appropriate for further statistical analysis. For evaluating causal and explanatory theories, data must be screened to ensure they are useable, trustworthy, and valid. Since secondary data from the 2011 TIMSS database were utilised in the current investigation, data editing and screening took the form of missing data treatment.

Missing is described by Little and Rubin (2019) as "unobserved values that would be meaningful for analysis if seen; in other words, a missing value obscures a meaningful value" (p.4). In research, missing data is one of the most significant statistical and design issues and cannot be put to the background. This is owing to its unfavourable impact on the investigation's data analysis outcomes. In terms of data analysis, researchers and psychometricians have referred to missing values as "nuisance" (Shin, Davison & Long, 2017; Hair, Black, Babin & Anderson, 2014). Consequently, untreated missing data have the potential to muddy the outcomes and interpretations of the data analysis.

Even though dealing with missing data is not the subject of this study, failure to do so adequately generates significant issues. First, missing data can add potential bias in parameter estimate and reduce the conclusions' generalizability (Schafer, 1997; Rubin, 1987). Second, neglecting situations with missing data results in the loss of data, which reduces statistical power and increases standard errors (Peng, Harwell, Liou & Ehman, 2006). McKnight, McKnight, Sidani, and Figueredo (2007) also reported that statistical power (i.e., the chance of rejecting a null hypothesis if it is wrong) is directly proportional to sample size. Statistical power diminishes as sample size reduces due to the removal of incomplete cases (McKnight et al., 2007). Third, missing data may constitute a substantial risk to the dependability and validity of the statistical results, and hence to the credibility and generalizability of the study's conclusion (McKnight et al., 2007). Fourth, most statistical processes, such as the present statistical procedure (HLM) employed for data analysis (Schaefer & Graham, 2002), are designed for complete data.

Before a data set containing missing values can be analysed using these statistical processes, it must be "completed" in some way. Inadequate data editing can render data inappropriate for a statistical technique and make statistical studies susceptible to assumption violations. Foy and O'Dwyers (2011) suggest that missing data makes it hard to use advanced statistical models like HLM because it makes it more difficult to keep sample sizes and degrees of freedom the same as variables are added or removed from the models. Lastly, because TIMSS data contain a wealth of information on the primary determinants believed to predict student progress in mathematics, incomplete cases result in a loss of statistical power in the analysed data as well as the risk of bias in the estimates of interest (Little, 1992; Little & Rubin, 2002).

Missing Data Treatment

Psychometricians have discounted missing data as a nuisance in large-scale educational examinations employing multistage sampling approaches, such as the TIMSS assessments (Acock, 2005; Allison, 2002; Pigott, 2001; Stevens, 2012; Streiner, 2002; Chepete, 2008). Examining data from earlier iterations of the TIMSS demonstrates that survey respondents, whether they are students, instructors, or school administrators, do not complete all questions on their questionnaires. According to Foy and O'Dwye (2011), missing data is prevalent in all national data files and at all levels, including schools, teachers, parents, and students. When there is missing data at a higher level, it often makes the missing data at a lower level worse. For example, if a school administrator fails to complete or submit a questionnaire, information regarding hundreds of students at that school is jeopardized (Chepete, 2008). Literature on how to deal with missing data has highlighted two primary approaches: (a) discarding incomplete information (the deletion technique) and (b) estimating values for missing data (the imputation method) (Chepete, 2008; Enders, 2010). The deletion method of handling missing data refers to the elimination or deletion of all cases with missing values on variables from the analysis.

The Deletion Methods of Treating Missing Data

The deletion procedure is the simplest and most often used approach for addressing missing data. According to Peugh and Enders (2004), deletion strategies are by far the most prevalent method for addressing missing data in a variety of social and behavioural scientific disciplines.

Listwise deletion, also known in the contemporary literature as "full case analysis," and pairwise deletion, also known as "available-case analysis," are the two primary deletion approaches. Listwise deletion (LD) eliminates from analysis those records lacking values for any variable (Allison, 2002). Specifically, the analysis excludes any "case" (e.g., participant) with at least one missing value on one or more variables (e.g., weight and height). In lieu of dropping cases, dropping variables with a significant proportion of missing values is another form of Listwise deletion (Tabachnick & Fidell, 2001). According to Chepete (2008), this alternative is considered if the variables are not essential to the study.

Another popular deletion approach, and another SPSS default for several studies, is pairwise deletion (e.g., linear regression and correlations). In the pairwise deletion technique, all cases with scores on each variable or set of variables are utilised in the study (Allison, 2002). Pairwise deletion, also known as available-case analysis, aims to address the issue of data loss associated with Listwise deletion (van Buuren, 2018). Conceptually, pairwise deletion appears to be advantageous because it makes use of all accessible data. However, the sample size varies among variables based on the number of missing data per variable (Chepete, 2008). Pairwise deletion has an advantage over Listwise deletion in that it uses all available variables and cases, resulting in little or no data loss (Ker, 2016). As a result, in pairwise deletion analyses, all cases and variables with observed values are used (Ker, 2016).

Substitution of Missing Data

One of the most common methods in dealing with missing values is the imputation procedure. The imputation methods replace a missing value with a plausible value through a statistical approach. Imputation is a frequent word for substituting reasonable values for missing data. Formally, imputation approaches require replacing missing values with appropriate plausible value and then filling in the data with standard complete-data procedures.

Missing data imputation processes are classified into two types: those that impute values only once (single imputation) and those that employ multiple imputations (IM) (Chepete, 2008). Single imputation procedures substitute one missing value for another, whereas the MI procedure substitutes one value for numerous values (Ker, 2016). Single imputation derives its name from the fact that each missing data point is replaced with a single value (Enders, 2010). Enders added that this differs from multiple imputations, which makes several copies of the data set and imputes each copy with distinct plausible estimates of the missing values. The following methods of single imputation for addressing missing data will be discussed: (a) mean substitution), (b) regression imputation, and (c) maximum likelihood substitution.

Mean Substitution

“Mean imputation and regression estimation are examples of methods that once impute data” (Chepete, 2008, p.86). Mean imputation is the process of replacing a missing value with the variable's mean or the mean of a subgroup when stratified sampling is used (Chepete, 2008). According to Graham (2012), mean substitution is a method in which the variable's mean is computed based on all cases with data for that variable. This mean is then used to replace any missing value in the variable in question

Regression Imputation

In addition to the mean imputation method, there is also the regression imputation method. Regression imputation, which is sometimes called "conditional mean imputation," fills in missing data with predicted scores based on other independent variables that don't have any missing data (Chepete, 2008). The variable with missing data is the dependent variable. Cases with complete data and the other independent variables are used to make the regression equation (Tabachnick & Fidell, 2001; Enders, 2010). Variables tend to be interconnected; therefore, it makes sense to generate imputations that utilise information from the observed data. In truth, regression imputation, maximum likelihood, and multiple imputations all utilise observed data information, but maximum likelihood and multiple imputation do so in a more complex manner (Enders, 2010)

Maximum Likelihood Imputation Techniques

The full information maximum likelihood (FIML) algorithm and the expectation maximisation (EM) algorithm are two extensively used maximum likelihood (ML) estimate algorithms for missing data imputation (Chepete, 2008). In every ML strategy, observable data is utilised to estimate parameters, which are subsequently used to predict missing scores. The two strategies have proved their superiority over the standard data management techniques described previously (Schafer & Graham, 2002; Peng et al., 2006; Allison, 2003). EM is a typical strategy for producing ML estimates with partial data that has been demonstrated to reduce bias resulting from missing data (Peugh & Enders, 2004). EM is a two-step, iterative imputation process in which the missing data's expected values are modelled using the observed values to yield predicted parameter estimates, which are then re-imputed for the missing values (Ker, 2016).

Missing Data in TIMSS

Missing data is common in behavioural and social sciences investigation for several reasons (Enders, 2010; Tabachnick & Fidell, 2007; Longford, 2008), and TIMSS data is no different. Prior to undertaking statistical analysis, the problem of missing data must be handled in large-scale surveys such as TIMSS (Butakor, 2015). Examining data from previous iterations of the TIMSS reveals that survey respondents, whether they are students, instructors, or principals do not complete all the items on their own questionnaires (Bouhlila & Sellaouti, 2013). Chepete (2008) revealed that, apart from school location and aggregated measures, every background variable used in the study had missing values in his analysis of TIMSS datasets (school variable means). At the student level, the percentage of variables with missing data ranged from 14.6 % (student educational aspiration) to 0.7 % (frequency of speaking English), while at the school level, it ranged from 11.6 per cent (teaching experience) to 0.7 % (teacher educational attainment) (Chepete, 2008). Butakor (2015) found that 6% of student data and 12% of teacher/school data were missing. He added that 40% of the 2007 and 2011 TIMSS datasets were missing. In addition, he revealed that 40% of the 2007 and 2011 TIMSS datasets were missing data.

Concerning the present study, which employs nested or multilevel structured TIMSS data in multilevel modelling analysis, missing value issues are more complex than in single modelling (Gibson & Olejnik, 2003). The complexity of missing data in multilevel analysis is a result of missing values at different levels of nested data. Ghagar et al. (2011) emphasise that missing data in multilevel structured data is more challenging because it might occur at multiple levels. In the case of two-level multilevel modelling, for example, if a level-2 unit (e.g., a school) has missing data and is omitted from the analysis, any observations (e.g., students) nested within that unit are also excluded from the study (Gibson & Olejnik, 2003).

The previous condition, according to Gibson and Olejnik (2003), makes it critical to handle missing values at the top of the hierarchy. Gibson and Olejnik revealed that in a two-level HLM analysis, multiple imputations for missing school-level data are troublesome and questionable. Multiple imputations, according to these researchers, alter estimates at level 2, which in this case is the classroom/school level. Two researchers found Listwise deletion and the expectation maximisation (EM) algorithm to be more dependable at level 2 for handling missing data. Chepete (2008) employed Listwise deletion and the expectation maximisation (EM) algorithm to handle missing data at level 2, as recommended by Gibson and Olejnik (2003), but multiple imputations to handle missing data at level one. The study conducted by Butakor in 2007 and 2011 filled in all missing student and teacher/principal values using maximum likelihood and expectation maximisation (EM) methods. Similarly, Ghagar et al. (2011) discovered that expectation maximisation is an effective method for replacing all missing student, teacher, and school values.

Treatment of Missing Data in the Current Study

Almost all the background factors or variables of the TIMSS 2011 data set for both countries used in this study had missing values. This was revealed by an explorative data analysis of the missing values. Descriptive statistics were run to detect the percentage of missing values for each variable considered for data analysis. The percentage of missing values among students' background variables ranged from a high of 10.4 (student value math) to a low of 1.6 (home educational resource) among classroom level data and from a high of 3.3 (major of study) to a low of .6 (teacher condition of service) among classroom level variables, according to the missing data analysis of Ghana's 2011 TIMSS data. A few variables at the school level have no missing data. For example, there was no missing data for the variable "parental support". The percentage of missing data among school level variables ranged from 1.9 (supplies such as papers and pencils) to 0.6 (arriving late at school). According to Singapore data, the percentage of missing data among student-level variables ranged from 2.1 (computer use at school) to 0.1 (I usually do well in mathematics), from 3.0 (lack of sleep) to.6 (professional development in math content) among classroom level variables, and from 4.2 (absenteeism) to 3.6 (arriving late at school) among school level variables. Furthermore, Little's MCAR test results revealed that data for both countries is not missing completely at random (NMCAR). It is also referred to as "nonignorable missing" (NIM). The outcome of the Little's MCAR test is very crucial in the sense that it drives or dictates the appropriate type of missing data procedure to be used in dealing with missing data. Since the current data is not missing completely at random, the deletion methods and traditional single imputation methods such as mean substation and regression were not appropriate, as revealed in the precited literature review on missing data (Butakor, 2015). For instance, using the Listwise deletion approach would have culminated in a 40% loss of the initial dataset, which might have affected severely the statistical power of the analysis. As indicated, using mean and regressing imputation methods would lead to biased estimates of population parameters. As a result, for the 2011 TIMSS data set, the maximum likelihood with expectation maximization (EM) algorithms in IBM SPSS statistics software version 20 were used to replace all missing data at both the student and classroom/school levels. This method of dealing with missing data was employed for both countries.

Variables Selected for Analysis

The variables selected for this thesis were founded on some considerations; for instance, factors that can easily be manipulated through policy in the Ghanaian education system if found to contribute significantly to mathematics achievement in the Singaporean education system. Since the aim of this thesis was to compare the two education systems (Ghana and Singapore) using the Singaporean education system as a reference point, with the view of learning from the Singaporean education system.

TIMSS collects a tremendous quantity of contextual information about the curriculum, schools, teachers, and students in addition to assessing mathematical proficiency. TIMSS 2011 used four different types of questionnaires to assess student, teacher, school, and curricular characteristics. Hundreds of contextual factors or items are included in the TIMSS 2011 databases. The contextual data is gathered to assist policymakers, researchers, and others in understanding student performance in their respective countries (Mullis et al., 2012). The majority of TIMSS 2011 context questionnaire components, such as student, teacher, and school surveys, included both single items and cluster/composite indicators. It would be extremely inconvenient to report all this information item by item.

As a result, the TIMSS researchers produced and made available to the public both continuous scale and index variables for each context variable (Mullis et al., 2012; Martin et al., 2016). So, these items were made to be put together into dimensions that measured a single underlying latent concept. This is called unidimentionality (Martin et al., 2012). Combining many items into one variable may have various advantages over single-item measurements, including better measurement precision, scope, and validity (Spector, 1997). Similarly, when there is a big amount of data to be reported, constructing summated rating scales is a method of minimising the amount of data and making it easier to digest (Mullis et al., 2012). Thus, continuous scales and indices in the TIMSS 2011 database were preferred to single-item statements whenever they were available.

Students Level Variables Selected for Both Countries

Out of the numerous variables made available in the 2011 TIMSS database, seven variables were selected at the student level; Student Confidence in Math (SCM), Student Like Doing Math (SLM), Student Math Valuing (SMV), Engaged in Math Lessons (EML), Students Bullied at School (SBS), Educational Expectation (EE), and Frequency of Homework (FH).

The variables for the study at the students' level comprised both single and multiple indicators of items. Examples of single-item indicators are educational expectations, and the frequency of homework. In terms of educational expectation, students were asked "how far in your education do you expect to go?" Students were given the following options from which to choose: (a)" "Finish Level 2: (a) Finish Level 3: (a) Finish Level 4: (b) Finish Level 5B: (c) Finish Level 5A, first degree: (d) beyond level 5A, first degree: (e) I don't know". Furthermore, students were asked, "How often does your teacher give you homework in mathematics?" The response options for this item were "every day", "3 or 4 times a week", "1 or 2 times a week", "less than one a week", and "never".

SCM, SLM, and SVM are examples of index variables in the TIMSS 2011 database. These index variables consisted of 24 items which related to the attitudes of students towards math. Students were asked, (1) "How much do you agree with these statements about learning mathematics? (2) I enjoy studying mathematics, (3) I wish I did not have to study mathematics, (4) Mathematics is boring, (5) In mathematics, I learn a lot of interesting things, (6) I would like to take more mathematics, (7) Mathematics is more difficult for me than for many of my classmates, (8) I enjoy studying mathematics, (9) It is important to do well in mathematics, (9) Mathematics is not one of my strengths, (10) I learn things quickly in mathematics, (11) I usually do well in mathematics, (12) Mathematics is more difficult for than for many of my classmates, (13) I am a quick learner in mathematics, (15) Mathematics makes me confused and nervous' (16) I am good at working out difficult mathematics problems, (17) My teacher thinks I can do well in mathematics programs /classes/lessons with difficult materials (18) My teacher tells me I am good at mathematics, (19) I find mathematics to be more difficult than other subjects, (20) I think learning mathematics will help me in my daily life, (21) I need mathematics to learn other school subjects, (22) I need to do well in mathematics to get into the university of my choice, (23) I need to do well in mathematics to get the job I want, (24) I would like a job that involves using mathematics". "The response options for all 24 items were agree a lot, agree a little, disagree a little, and disagree a lot".

Classroom/School Level Variables for Both Countries

The fourteen factors that were selected at the classroom/school level are namely; School Discipline and Safety (SDS), Safe and Orderly Schools (SOS), Teachers' Experience (TE), School Emphasis on Academic Success (SEAS), Frequency of Test (FT), Teachers Majoring in Education and Math (TMEM), Mathematics Teachers' Formal Education (TFE), Instruction to Engaged Students Learning (IESL), Teacher Condition of Service (TCS), Confidence in Teaching Math (CTM), Instruction Affected by Math Resource Shortage (IAMRS), School Size and Class Size. The variables for the study at the classroom/school level also comprised both single and multiple indicators of items. Examples of single-item indicators are the frequency of tests, school size, class size, and teachers' formal education. In terms of school size, the principals of schools were asked, "What is the total enrolment of students in your school as of the first day of the month TIMSS testing begins, 2010/2011?" Teachers were asked about their formal education, "What is the highest level of formal education you have completed?" Examples of school level index variable are SDS, SOS, and SEAS. In terms of SDS, school principals were asked "to what degree is each of the following a problem among eighth-grade students in your school? (1) Disruption in the classroom, (2) Cheating, (3) Profanity, (4) Vandalism, (5) Theft, (6) Physical injury to other students (7) Intimidation or verbal abuse of teachers or staff (including texting, emailing, etc.), (8) Physical injury to teachers or staff".

Most context questionnaire items in TIMSS 2011 were intended to be grouped into scales measuring a single latent concept. In accordance with the international TIMSS achievement benchmarks, each context scale was separated into areas corresponding to high, medium, and low construct values. By expressing the cut points as combinations of answer categories, (Mullis et al., 2012) makes it easy to understand what the regions represent.

Weighting Issues

TIMSS utilised a two-stage stratified cluster sampling approach as opposed to a simple random sampling design, with schools as the first stage and intact classrooms (with all students present) as the second stage (Olson, Martin, & Mullis, 2008). TIMSS employs a method of sampling in which the likelihood of sample unit selection at each stage is unequal. When evaluating data at several levels, it is necessary to apply suitable sampling weights to the different levels of data in order to get conclusions that represent the features of the population and obtain impartial population statistics (Butakor, 2015). The purpose of sampling weighting is to rectify the systematic differences in probability sampling. Downloadable weighting variables are provided by TIMSS alongside the data. These are the variables used for weighting: TOTWGT equals the sum of all students' sampling weights. This is essential when population parameter estimations from students are desired. The advantage of adopting TOTWGT is that it ensures that many groups within the sample are represented proportionally and accurately when calculating population estimates (Harmouch et al., 2017). Senate Weight (SENWGT) is the sum of the sample weight of 500 students in each country, regardless of the student population size in each country. HOUWGT equals the sum of the sample sizes of students in each country. HOUWGT is a modification of TOTWGT that assures the weighted sample size in each country corresponds to the actual sample size. TIMSS delivers HOUWGT to avoid the difficulties (Harmouch et al., 2017). The Math Teacher Weight (MATWGT) is an important classroom sample weight. It is used while analysing data from both students and teachers. It is also used to estimate the number of students and instructors. The school weight (SCHWGT) is calculated as the non-participation compensation factor for that school multiplied by the reverse of the likelihood of selecting a school (Mullis et al., 2005). According to Rutkowski et al. (2010), student senate weight (SENWGT) should be employed at the student level if a study includes data from more than one country, as is the case with the current study (Ghana and Singapore). Butakor (2015) emphasized that Senate Weight is helpful for global calculations since it treats each country purely based on its student population when establishing implications and producing worldwide conclusions. For instance, Ghana's eighth-grade population is expected to be greater than 3 million, whilst Singapore's eighth-grade population is slightly over 84,000.

The Ghana option would predominate in an analysis comparing the effect of gender on achievement in these two nations using total student weight. Cross-country analyses in TIMSS and PIRLS add senate weight to account for differences in population size. Senate weight is the student's total weight scaled so that the sum of all senate weights in each country equals 500. Thus, SENWGT and MATWGT were utilised at the student and classroom/school levels, respectively (Olson et al., 2008).

Centering Issues

Scaling or centering of independent factors (variables) in multilevel research is the process of subtracting a reference value, typically the average or mean, from all individual raw scores on any independent variable and transforming the raw system of measurement into the standard deviation from the mean or average score (Tabachnick & Fidell, 2007; Wu & Wooldridge, 2005). According to Kreeft and de Leeuw (1998), the aim of centering predictor variables is to alter the interpretation and meaning of the intercept. Butakor (2015) argues that centering is significant in hierarchical linear modelling because it simplifies the interpretation of the intercept and gives it meaning. In multilevel modelling and regression analysis in general, the intercept is defined as the predicted score on an outcome factor or variable for a model subject whose scores on all predictors are zero (Raudenbush & Bryk, 2002). Social science and education variables lack significant zero values (Kreeft & de Leeuw, 1998). This is because most variables in education (e.g., student achievement scores) are measured on an interval scale in which a score of zero does not reflect the absence of the concept/trait in question. In these instances, the intercept is understood as the expected score on the dependent variable for an individual whose scores on the independent variables are equal to the group mean or grand mean, depending on the type of centering strategy utilised (Ghagar et al., 2011).

The HLM tool for analysing multilevel or hierarchical data offers three methods for centering the level-l variable (Raudenbush et al., 2004). The variables are (a) raw metric (uncentered), (b) group mean-cantered, and (c) grand-mean cantered. Grand mean centering is the strategy most frequently employed in multilevel modelling (Hox, 2002; Enders & Tofighi, 2007). The grand mean reduces the multicollinearity between predictor variables (Tabachnik & Fidell, 2007; Kreft, & De Leeuw, 1998; Hofmann & Gavin, 1998).

Multicollinearity is the presence of linear or nearly linear correlations between predictors, explanatory, independent, or input variables in a model of any given person or collection of response, dependent, criteria, or outcome variables (Tong, 2002). Multicollinearity therefore happens when the predictor variables in a regression model are interrelated. In multilevel analysis, multicollinearity poses a hazard to the estimate of the model's parameters. In their investigation, Shieh, and Fouladi (2003) found that multicollinearity introduced bias when estimating intercepts and correlation coefficients. Reduced precision in the estimation of coefficients diminishes the statistical validity of the regression model. It also decreases the efficacy of the regression model to discover statistically significant independent variables and makes the interpretation of regression parameters very difficult. Using grand-mean centering, it is possible to resolve the aforementioned major issues (Frost, 2019). As a result, grand mean centering was used in this study for all explanatory variables and covariates (Hox et al., 2017). The intercept equals the school average for Level 1 student achievement and the grand average for Level 2 student average, when the predictor variables are grand-mean centred (Snijders, & Bosker, 2011; Raudenbush, & Bryk, 2002; Hox, 1995).

Checking Assumptions

Normal distribution of residual errors, multicollinearity, and outlier constitute important assumptions of the multilevel analysis. The violation of these assumptions may produce inaccurate parameter estimates and inflated standard errors. Hence, the importance of checking assumptions before data analysis.

Normality

Multilevel linear models assume that the random error at level 1 has a normal distribution (Raudenbush et al., 2004). After fitting the final model, the HLM computer software, which was utilised for data analysis in this work, provides the ability to test the model's distributional assumptions by producing residual files (Harmouch et al., 2017). Residual files contain the difference between the observed and fitted dependent variable values. Using the level-1 residual files, a probability plot (Q-Q) was constructed for both countries (Appendix C). According to Raudenbush et al. (2004), the random errors are regularly distributed if the Q-Q plot resembles a 45-degree line. The examination of the two math Q-Q plots for both Ghana and Singapore reveal that they are approximately linear and resemble a 45-degree line. This demonstrates that both Singapore and Ghana have genuine normal error distributions for math achievement scores.

Multicollinearity

Multicollinearity refers to a high level of intercorrelation between predictors or independent variables. Performing a correlation matrix between the predictors is one method for identifying multicollinearity. A correlation coefficient greater than 0.80 (Field, 2009) or 0.90 (Orme & Combs-Orme, 2009) is indicative of multicollinearity. Multiple correlation matrices were built in order to examine the multicollinearity of predictors at level one. For the correlation matrix, the mean of five plausible values was utilised as the predicted variable. Greater correlations existed between predictors and the dependent variable than between the independent variables themselves. According to Tabachnick and Fidell (2007), any correlation coefficient among predictors surpassing 0.90 is indicative of a multicollinearity issue. According to the correlation matrix that was developed, the correlation between the predictors was significantly lower than 0.90. Therefore, it was determined that multicollinearity was not an issue.

Outlier

Despite the usefulness of multilevel models for handling nested or multilevel data, they are vulnerable to outliers appearing at each level (student, classroom, school) of the data, resulting in estimate bias and inaccurate standard error (e.g., Kloke, McKean, & Rashid, 2009; Seltzer & Choi, 2003). An outlier or "outlying" observation in a data set is an observation that is discordant with the rest of the data. In multilevel or nested data, multilevel outliers present a tad more difficulty. This is because an outlier might exist at any level of the data structure. An outlier may originate, for instance, from an independent variable at the student level. The dependent variable may also contain an outlier.

According to Mohammedpour (2012), to identify an outlier in the dependent variable, the set of five plausible mathematics achievement values should be converted to standard z scores. If the variable follows a normal distribution, then 99 per cent of the scores should lie within three standard deviations of the mean (Hair, Anderson, Tatham, & Black, 1998). In the current study, the assessment of outliers revealed that just six cases were within one of the five possible values that were somewhat above the mean.

Stevens (2012) suggested that when the sample size is greater than 100, as it is in this study, a small number of scores will likely exceed. In the instances, the minimum value of the standard score can be increased (Hair et al., 1998).

Control of Variables

The current study is basically an effective school research project, as indicated by the model used in this study. Effective schools are defined as ones that have a positive effect on students' learning, independent of the background of the home. Therefore, the focus is to isolate factors that make classrooms or schools effective independent of students' characteristics like home background and gender. These are individuals' characteristics that the school has the least capacity to modify or influence. To do this, home education resources and gender concepts were controlled in this analysis.

Research studies reveal that gender inequalities in mathematics achievement persist in various nations, but their direction varies (e.g., Mullis et al., 2012). There is an even higher correlation between socioeconomic status and academic performance (Mullis et al., 2012).

IDB Analyser's preliminary multiple regression analyses of this study revealed that both home educational resources and gender were important contributors to the mathematical achievement of eighth-grade students in both nations. The preliminary investigation also found a gender difference in mathematics achievement between the two nations. For example, eighth grade boys in Ghana did better than girls, whereas eighth grade girls in Singapore performed better than boys. This conclusion is consistent with past research finding indicating that gender inequalities in math proficiency among students persist but vary in direction (Mullis et al., 2012). In both nations, preliminary

HLM analyses revealed a positive and significant association between gender and math achievement. The HLM analysis also validated previous finding that there was a significant gap in math performance between boys and girls in both countries.

Consequently, it was necessary to control these factors in the analysis. To assess the association between classroom/school factors and their primary contribution to eighth-grade students' mathematics achievement, it was necessary to account for students' home education resources and gender in the analysis.

Hierarchical Linear Modelling of School Effectiveness

De Leeuw (2004) believes that multilevel modelling techniques are intended to separate the impacts of explanatory variables at several hierarchical levels. According to Hox (2002), HLMs are the most prevalent of these. Multilevel modelling tries to reveal the unique connection between higher-level variables (e.g., classroom/school) and lower-level variables (e.g., students) and the dependent variable, considering any relationships that may exist within and among the levels (Ker, 2016). Hierarchical Linear Modelling (HLM) analysis methodologies were used in this thesis to analyse the contribution of predictor factors at the student level and classroom/school level for TIMSS data from Ghana and Singapore in 2011 using HLM.

Justification for the Use of the HLM Statistical Tools

Students are nested within classes and classrooms are nested within schools, as previously stated, hence HLM was used to analyse the data. Nesting indicates that observations are not entirely independent of one another; for example, students in the same classroom have a shared teacher, a common classroom climate, a common group of classmates, etc.

HLM is a more recent and sophisticated statistical analytic technique that permits researchers to conceptualise the impacts of contextual factors on student achievement as occurring on multiple levels (e.g., students, teacher, and school). The hierarchical linear model is a form of regression analysis for multilevel data in which the dependent variable is situated at the lowest level. The nature of the nested structure of educational data (i.e., students nested within classrooms and classrooms nested within schools) is an example of multilevel data. The nested or multilevel structure of TIMSS data, in which students are nested inside classes and classrooms are nested within schools, makes the HLM an effective statistical tool for the current data analysis.

The literature review on statistical methodologies also indicates that about 90% of the studies that analysed TIMSS data adopted or employed HLM as the most appropriate statistical tool for the analysis (Mohammedpour, 2012; Chung, Lee & Kim, 2014; Butakor, 2016; Aru & Kale, 2019; Ersan & Rodriguez, 2020; Chan, 2022). This is because of the nested nature that characterizes TIMSS data.

The HLM statistical tool was selected over standard ordinary least square (OLS) regression, also known as multiple regression, because of the deficiencies of OLS regression in handling nested data. In OLS regression analysis, a statistical model identifies a collection of variables (independent variables) and uses them to predict another variable (the dependent variable). OLS regression analysis generates a statistical model that depicts the strength and direction of the link between a certain independent variable and the dependent variable, while controlling (keeping constant) all other independent variables in the model (O'Dwyer & Parker, 2014). Here, the focus is on prediction models with a single changing dependant variable.

In light of the above comments, multiple regression analytical techniques cannot handle the nested data of this investigation adequately. Thus, multiple regression will attempt to analyse the levels of the data independently without taking into account the nested nature of the data. For instance, the single-level regression model cannot take into consideration that the students may be clustered within a number of schools with other students having similar background and scores on dependent variable (Math).

Consequently, the HLM method was used for the data analysis. A further advantage of multilevel modelling is that the variance component can be partitioned across the data levels (e.g., students, classroom, and school). While OLS regression provides a single value indicating the proportion of variability in the dependent variable that can be explained by the independent variables (referred to as R^2), the multilevel model's more complex error term permits partitioning the total variance in the dependent variable into a within-group component (student-to-student variation within schools, for example) and a between-group component (variation between schools, for example).

It also allows you to determine how much variation is reduced when independent variables are added at both the individual and group levels in subsequent models (O'Dwyer & Parker, 2014). The available variance in the dependent variable is partitioned into its within-group variance (σ^2) and between-group variance (τ_{00}) components using an unconditional multilevel model that includes only a random group effect. The intraclass correlation coefficient (ICC) is used to calculate the portion of variance in the dependent variable that is explained at each level.

Hierarchical Linear Modelling Analysis

Even though data came from school principals, teachers, and students, the Ghana sample consisted of an equal number of teachers and schools. That is, each school had only one teacher. Because the study only looked at one classroom and one teacher in Ghana, it couldn't compare the effects of different classrooms and teachers within schools. “Singapore added a third sampling stage to the TIMSS's standard two-stage sampling methods; students were randomly selected from two classrooms within each designated school” (Ghagar et al., 2011, p. 211). Thus, it made it likely to compare the mathematical performance of students across classrooms within schools. Since this is a comparison study, it may not be suitable to compare two countries utilising distinct multilevel modelling techniques (i.e., two-level and three-level). As a result, a two-level multilevel modelling strategy was utilised to analyse the data from Ghana and Singapore. In this analysis only the intercepts, which correspond to the averages of the school, were allowed to vary but the predictor coefficients were fixed. A fixed slope model and a random intercept model were employed in this analysis. Thus, student level intercept, which indicates the school average if all level 1 variables or predictors were cantered on the grand mean, varied between schools, although the gradient or slopes of the level 1 predictor variables remained constant.

There were five HLM analyses conducted. First, the total possible variance to be explained at each level was estimated by the null model, which has no covariates or predictor variables at both classroom/school and student levels. Secondly, the control variables were then incorporated into the null model. Thirdly, to generate a preliminary estimate of the contribution of each student level variable to the math achievement of students, student-level factors were added to the control variable model, which had gender and family educational resources as control variables. At the classroom/school level, the same analysis was also undertaken. Finally, a full analysis of all students and classroom/school level was conducted.

Intercept-Only or Unconditional Model

This stage of analysis involves the employment of an empty or null model to estimate how much variance there is in the dependent variable (math achievement between or within schools). The null model can determine two important criteria for HLM analysis: is there enough difference or variance between students and classrooms/schools to justify using multilevel modelling investigation; and if so, how much of this difference is due to variation between students and classrooms/schools?

The equation for the unconditional model representing a two-level model is:

$Y_{ij} = \beta_{oj} + \varepsilon_{ij}$ $\beta_{oj} = \gamma_{00} + u_{oj}$. Through substitution, the empty modal can be written as

$Y_{ij} = \gamma_{00} + u_{oj} + \varepsilon_{ij}$.

where Y_{ij} represents achievement of student *'i'* in school *'j'*; β_{oj} represents the intercept of school j or the mean of school j; γ_{00} is the intercept representing the grand mean; u_{oj} is the school level intercept variance from the grand mean for school *'j'*; ε_{ij} is the error term representing the unique effect associated with student *'i'* in school *'j'*. The error term represents the difference between a school's mean and the actual score of a student within school 'j' (Heck, Thomas & Tabata, 2014).

This model also provides a measure of dependence within each level 2 unit by way of the intraclass correlation (ρ). The intra-class correlation (or ICC) describes the proportion of variance that is common to each unit, as opposed to variation or differences that is associated with individuals within their units (school or class). It can be thought of as the population estimate of the amount of variation or difference in the outcome variable (math achievement) explained by the grouping structure (e.g., school) (Hox, 2002). The ICC can be represented as:

$$\rho = \frac{\tau_{00}}{(\tau_{00}+\sigma^2)},$$

Where τ_{00} and σ^2 represent the variance or difference between and within groups respectively. In other words, the ICC is the ratio of between-groups variance to the total variance. Heck, et al. (2014) indicated, the higher the ICC, the more homogeneous are the units (i.e., there exist substantial difference or variability between schools). In contrast, if the ICC is very small (i.e., researchers often use 0.05 as a raw "cut-off" point) in this case there would be little advantage to conducting multilevel analysis. In these cases, a single level analysis (i.e., OLS or multiple regression) conducted at the individual level would suffice (Heck, et al., 2014).

Level-1 Model (Student level)

In HLM model development, according to Raudenbush and Bryk (2002), a series of typical regression analyses are conducted first, beginning with the most theoretically significant predictor variables, and then adding predictor variables in order of relevance (Butakor, 2015). The initial analysis in this study focused on students. At level 1, math achievement is expressed as a linear combination of all student factors, whereas the classroom/school model is expressed as the null model (i.e., no predictor). In this phase, each of the student variables was entered individually into the null model in descending order of importance in order to examine the impact of these variables on math attainment (Butakor, 2015). This analysis sought to determine the effect or contribution of each student-level variable on or to mathematics success in the presence of other student-level variables.

The student level equation is therefore represented as:

$Y_{ij} = \beta_{oj} + \beta_{1j}\, X_{1ij} + \beta_{2j}\, X_{2ij} \ldots\ldots +u_{oj} + \varepsilon_{ij} \quad \beta_{oj} = \gamma_{00} + u_{oj}$

where Y_{ij} refers to the achievement for the ith student in school 'j', β_{oj} is the student level intercept in school and β_{1j} is the regression coefficient or slope for student level variable X_1 . The coefficient measures the relationship between X_1(a predictor variable of the ith student) in school 'j' and their achievement in school 'j'. The deviance representing departure from the grand mean for the mean of school 'j' is u_{oj} while ε_{ij} is the difference between the actual score for students 'i' and their predicted score under the model for school 'j'.

Classroom/ School Level Model

At this stage, the predictor variables of interest at the classroom/school level are introduced and incorporated into the model equation. School averages, also known as level-1 intercept, were used as a dependent variable to assess the contribution of classroom/school variables to students' mathematics attainment. Like level one model construction, classroom/school level factors were incorporated at level 2. An estimate of the contribution of the classroom/school to students' achievement is represented as:

$$\boldsymbol{Y_{ij} = \gamma_{00} + \gamma_{01}\ X_{1j} + \gamma_{02}\ X_{2j}\ \ldots + u_{oj}\ +\ \varepsilon_{ij}}$$

where γ_{00} is the intercept representing the grand mean; γ_{01} is the coefficient (slope) measuring the effect of X_1 which is level two variable on Mathematics achievement and γ_{02} is the coefficient of X_2 estimating the contribution of X_2 to students' achievement. The departure from the grand mean for the mean of school 'j' is represented by u_{oj} and ε_{ij} is the error term representing a unique effect associated with student 'i' in school 'j'

Full Model

Integrating the equations from the students' model and the classroom/school model produced the following equation for the complete model: $Y_{ij} = \beta_{oj} + \sum_{q=1}^{Q} \beta_{qi} X_{qij} + \varepsilon_{ij}$ $\beta_{oj} = \gamma_{qo} + \sum_{s=1}^{sq} \gamma_{qs} W_{sj} + U_j$ In the comprehensive model, the whole sets of student and classroom/school variables are incorporated. The objective of the comprehensive model analysis was to simultaneously assess the effects of student and classroom/school-level factors on mathematics achievement. In other words, the full model was estimated in order to determine which variables were crucial at each level of analysis. This was accomplished by considering the relationships between these factors both inside and between the two levels. The 2011 datasets were analysed with the help of the statistical tool HLM 8.2 (Raudenbush et al., 2019). Typically, the data analysis consists of three steps: (a) generation of the multivariate data matrix (MDM) file, (b) analysis with the generated MDM file; (c) evaluation of the model fit with the residual file and findings (Raudenbush et al., 2019).

Summary

This session summarizes the procedures followed in this current investigation. Firstly, the research design adopted for the study, the study's philosophical position, TIMSS, data source, population, sampling procedure, instrument and data collection procedures were examined. Secondly, processing and analysis of data, which includes TIMSS data cleaning and entry procedures, missing data, and management, were also discussed. Thirdly, justification of the selection of variables for the study, HLM assumption issues such as weighting, centering, multicollinearity, and outliers were addressed. Finally, various HLM equations connected with the different levels of analysis were presented.

CHAPTER FOUR

RESULTS AND DISCUSSION

The main intent of this study was to make comparison between Ghanaian and Singaporean grade eight students in terms of their math achievement using TIMSS 2011 with the view of learning from the Singaporean education system which facilitates high math achievement. The study specifically focused on which of the two levels (student, classroom/school) of the school system significantly drives the learning of mathematics in the two countries. The study also examined which of the student-level factors; classroom/school-level contextual variables measured in the TIMSS 2011 were the best or strongest predictor(s) of math achievement of grade eight in the two countries.

The final sample for Ghanaian grade eight students in TIMSS 2011 consisted of 7,323 students nested within 161 teachers, which meant nested within 161 schools, after using the EM technique to substitute missing values at all two levels (i.e., students and classroom/school) for both countries. The average class size was 48.00 students, with class sizes ranging from 10 to 62 students. On the other hand, the final sample for Singapore eight-grade students in TIMSS 2011 comprised 5,251 students nested within 129 classrooms. Tables 10 and 11 show the descriptive statistics of the five plausible values for Ghana and Singapore respectively.

Table 10: TIMSS 2011 Five Plausible Values Descriptive Statistics For Ghana (N = 7323)

Plausible Values	Min	Max	Mean	Std. Deviation
First	39.33	655.73	335.01	85.62
Second	65.89	688.22	333.68	86.19
Third	57.37	710.76	331.60	86.82
Forth	39.01	660.21	331.56	86.74
Fifth	50.16	729.65	333.18	86.16

Table 11: TIMSS 2011 Five Plausible Values Descriptive Statistics For Singapore (N = 5251)

Plausible Values	Min	Max	Mean	Std. Deviation
First	335.21	811.47	606.22	83.19
Second	285.97	842.48	607.45	83.94
Third	303.91	858.45	608.15	84.60
Forth	309.78	833.30	607.79	84.31
Fifth	313.58	8387.70	608.12	83.56

Figures 4 and 5 present the frequency polygons for the first plausible value for Ghana and Singapore respectively. The figures for the other four plausible values are comparable for both countries (Butakor, 2015). The chart is fundamentally normal in shape as seen by the normal curve which is superimposed on the histogram.

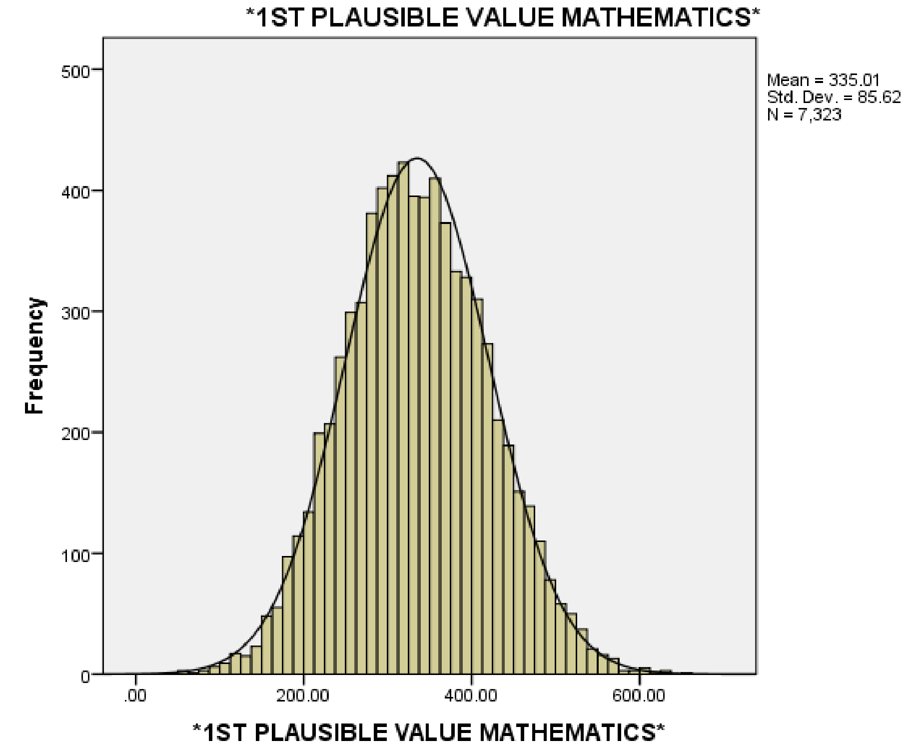

Figure 6: Frequency polygon for Ghana

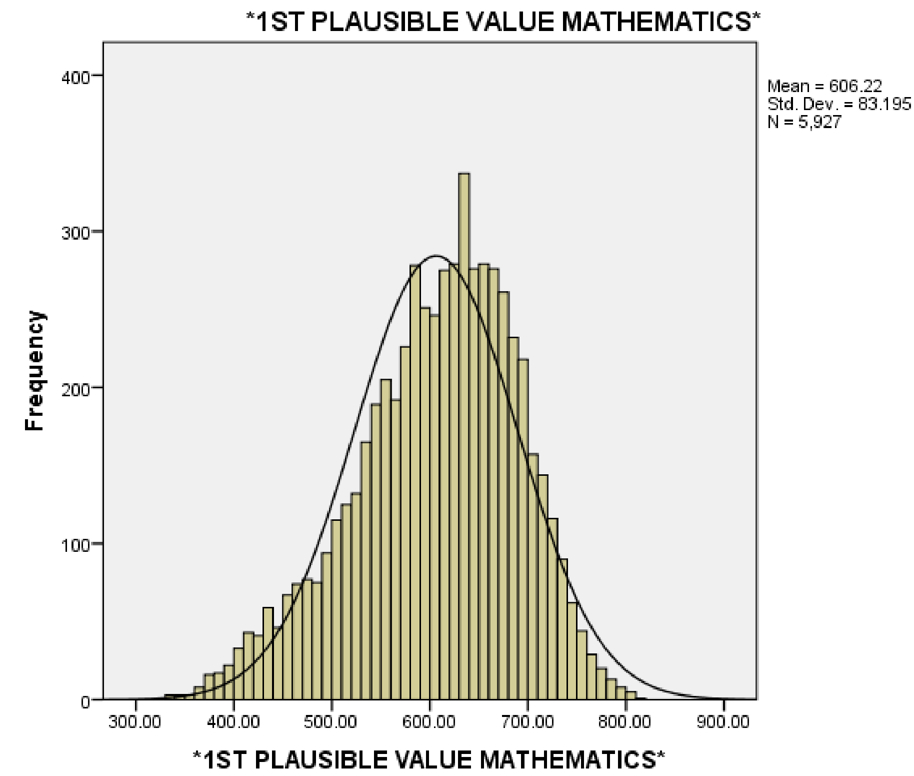

Figure 7: Frequency polygon for Singapore.

Results

Hierarchical Linear Modeling and Results

Hox (2010) and Muijs (2011) indicated that HLM is preferred statistical tool especially for analysing nested data for two main reasons. The first reason emanates from methodological considerations (the sampling method used in collecting the data) and the other is conceptual (exploring variances attributable to each predictor at different levels). The primary data sampling method used by TIMSS as indicated in Chapter Three of this current study (methodological reason) as well as the purpose of the study (conceptual reason) satisfied these two important conditions thus justifying the use of HLM technique (Nyatsikor, 2019).

At Level 1, there were seven student predictor factors and 14 classroom/school predictor variables. Appendix A contains a full description of each predictor variable, whereas Appendix C contains descriptive statistics for all selected variables for both countries. The findings are presented for both countries based on study's research questions.

Investigating the Research Questions

A total of three main research questions were examined. Research question one examines which one of the two levels has the most impact on the mathematics learning in Ghana and Singapore. Research question two investigates the contribution of selected student-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students. Research question three explores the contribution of selected classroom/school-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students.

Research question 1: Which of the two levels (student, classroom/school) has the most impact on the mathematics achievement of eighth grade Ghanaian and Singaporean students?

The answer to this research question was estimated using the null or unconditional model. The unconditional model is the empty or null model with no covariates variables at both levels (Butakor, 2015). This approach generates the so-called "intraclass correlation coefficient," which is a statistical measure (ICC). Table 12 shows the results of the null or empty model.

Table 12: Summary Results of the Null Model for Ghana and Singapore

	Ghana			Singapore		
Random Effect	Variance Component	Standard Deviation	p-value	Variance Component	Standard Deviation	p-value
τ_{00}	2968.87	54.48	<0.001	3014.19	54.90	<0.001
σ^2	4323.79	65.76		3915.81	62.57	

The estimated grand average of math achievement scores (γ_{00}) based on the analysis for Ghana is 331.04 and with a standard error of 5.21. In contrast, the grand mean mathematics achievement score for Singapore is 605.72 with standard error of 4.34. Table 12 displays estimated variance components at the student-level (σ^2= 4323.79 and 3915.81) and at the school-level (τ_{00}= 2968.87 and 3014.19) for Ghana and Singapore respectively. This gives a total estimated variance of 7292.66 ($\sigma^2 + \tau_{00} = 4323.79 + 2968.87$) and 6930 ($\sigma^2 + \tau_{00} = 3915.8 + 30.14.19$) for the overall distribution of mathematics achievement for Ghana and Singapore respectively. The results of the total estimated variances for both countries indicate that the differences of mean math achievement are greater in Ghana than Singapore. The school-level variance (τ_{00}) is the variance in the distribution of the school's true means around the grand mean, as stated in Chapter Three (Chepete, 2008). The proportion of the variance in mathematics achievement of Ghanaian students that is between schools (i.e., intraclass correlation coefficient (ICC) (Chepete, 2008) was estimated by $\rho = {}^{\tau_{00}}/_{(\tau_{00} + \sigma^2)} = \frac{population\ of\ school\ variance}{Total\ variance}$ = 2968.87/ (2968.87 + 4323.79) = 0.4071. The ICC is conventionally expressed in percentages. As a result of the calculated ICC, approximately 40.71 % variance of the overall model variance can be attributed to differences among grade eight schools in Ghana that students enrol in, whereas about 59.29% (1- 0.4071) was due to differences among students. In contrast, the ICC for mathematics achievement of Singaporean students was 3014.19/ (3014.19 + 3915.80) = 0.43495. Thus, that 43.49% of the total variance of mathematics achievement can be as a result of differences between grade eight schools in Singapore that students enrol whereas about 56.51% (1- 0.43495) was due to differences among students. According to Chepete, the ICC test statistic represents the estimated correlation between pairs of scores in the 161 Ghanaian and 165 Singaporean schools that participated in this study. In other words, the ICC statistic also provides the degree of dependence of responses of people belonging to or sharing a class, contrary to the assumption of regression that students' responses are independent (Rowan, Raudenbush, & Kang, 1991; O'Dwyer, & Parker, 2014).

The null model also provides a significance test of these differences among schools. The null hypothesis tested is $H_0 = \tau_{00} = 0$. This is an ANOVA test of differences between school averages (Chepete, 2008). The chi-square test results for both Ghana ($x^2 = 5259.38$, $df = 160$, $p < 0.001$) and Singapore

(x^2 = 4929.83, df = 164, p <0.001) indicate significant difference among schools in their average achievement. Even though both countries operate centralised education systems, the ANOVA test of difference shows that Ghana and Singapore are not that similar in their performance as mentioned in this current study. The empty or null model also provides reliability estimate for the school sample mean estimations. The average reliabilities of school mean for Ghana and Singapore TIMSS 2011 were 0.95 and 0.97, respectively, indicating that the sample means are highly dependable as indicators of the actual school means for both nations.

The ICC calculated for eighth-grade mathematics achievement at school (40.71%) and (43.49%) for Ghana and Singapore respectively; were considered large enough to warrant further examination of the predictor variables using HLM relative to the guidelines set out by experts (Kreft & De Leeuw, 1998; Tolmie et al., 2011). The subsequent models aim to explain the observed variation between schools and students based on their context-specific properties.

There was the need to control some student variables in the analysis in order to isolate the contribution of classroom/school variables (e.g., school emphasis on academic success) on eighth grade mathematics attainment. To be able to do this, gender and home educational resource were controlled for in this analysis. The basis for the selection of these variables to be controlled in this analysis was elaborated in page 145 of this thesis.

The next step of the model development was to control the influence of variables in the dataset that were not of direct interest to the researcher but were thought to likely influence the results.

Controlled Variables Models for Ghana and Singapore

It can be observed from Table 13 that the introduction of the two variables to the null model resulted in changes in the percentage variances to be explained at all levels (students and classroom/school). At classroom/school level, the percentage variance to be explained rather increased from 40.71% in Table 12 to 41.8% in Table 13 for Ghana. Likewise, the percentage variance to be explained at student level in the case of Singapore increased from 56.51% to 58.53%. This is not an unfamiliar occurrence in HLM. It is like suppression effects sometimes found in standard multiple regressions (Stride, 2015). The increase in student level variance indicates that there is a connection between the variables (gender and home educational resources) introduced and both students and school level variance (Nyatsikor, 2019). Nyatsikor indicated that, true difference among schools that happened to be hidden in the unconditional/null model due to the absence of variables or predictors is revealed once these variables are controlled. In other words, the presences or introduction of control variables into the null model might reveal the true variation to be explained in the model. The *p*-values recorded for gender [$p < 0.001$; $p = 0.718$], home educational resources [$p = 0.279$; $p < 0.001$], suggested that gender and home educational resource were significant in explaining the differences observed in eighth grade mathematics achievement for Ghana and Singapore respectively. On the contrary, *p*-values recorded for home educational resources and gender were not significant in explaining the variation in mathematics achievement for Ghana and Singapore respectively.

Table 13: Results for controlled variables for Ghana and Singapore

	Ghana				Singapore			
Fixed effect	$\beta(SE)$	Variance to be explained %	Variance explained %	p-value	β (SE)	Variance to be explained %	Variance explained %	p-value
Intercept	330.63 (4.66)			<0.001	605.75 (4.15)			<0.001
Gender	-24.703 (2.30)			<0.001	0.65 (1.8)			0.718
Home Educational Resource	-4.43 (3.72)			0.279	17.7 (10.09)			<0.001
Random effect	**Variance component**			**p-value**	**Variance component**			**p-value**
Variance at classroom/school level (level, 2 u_0)	4169.95	41.8	0.036	<0.001	3858.51	41.5	1.46	<0.001
Variance at students' level (level 1, r)	2991.72	58.2	0.77		2733.08	58.5	9.33	

Students-Level Models (Ghana and Singapore)

Research question 2: What is the contribution of selected student-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students? Example: Student Value Mathematics**,** Students Like Learning Mathematics**,** Students Confidence with Mathematics**,** Students' Educational Expectation, Students Bullied at School, Frequency of Mathematics Homework, and Instruction to Engaged in Mathematics Lessons

To evaluate the contribution of individual factors on mathematical achievement, each factor was introduced separately to the students' model. In other words, to assist interpretation of the impacts of the seven contextual factors identified in the second research question on mathematics success, individual HLM were developed for each variable. (Bryk & Raudenbush, 1992: Bryk & Thum, 1989; Raudenbush et al., 2019).

In this model, only variables at the student level are introduced to the student level equation of the empty model (Butakor, 2015). In this study, the student-level variable was introduced to the control variables model (i.e., model 2). To answer this research question, seven HLM models were estimated and the results are displayed in Table 14. As indicated in Table 14, out of the seven student-level indicators six were statistically distinct from zero for both Ghana and Singapore. For example, Engaged in Mathematics Learning and Students' Educational Expectation were not significant for Ghana and Singapore respectively. Table 14 also included the results of effect size (f^2) for each variable introduced into the model.

Table 14: Summaries of Level One HLM Results for Ghana and Singapore

Fixed Effects	Ghana			Singapore		
	$\beta(SE)$	f^2 %	*p-value*	$\beta(SE)$	f^2 %	*p-value*
For INTERCEPT1, β_0 INTERCEPT2, γ_{00}	330.80 (4.65)		0.001	605.74 (4.16)		0.001
For Student Value Math slope, β_3 INTERCEPT2, γ_{10}	22.68 (2.42)	4.9	0.001	12.63 (1.44)	3.1	0.001
Students Like Learning Math slope, β_4 INTERCEPT2, γ_{20}	24.30 (1.67)	6.7	0.001	22.9 (1.21)	8.7	0.001
Students Confidence with Math slope, β_5 INTERCEPT2, γ_{30}	17.25 (2.06)	6.6	0.001	28.58 (1.68)	14.44	0.001
Students' Educational Expectation slope, β_6 INTERCEPT2, γ_{40}	10.81 (1.42)	5.6	0.001	0.84 (0.63)	1.7	0.184
Students Bullied at School slope, β_7 INTERCEPT2, γ_{50}	6.03 (2.13)	2.25	0.008	11.41 (1.25)	1.74	0.001
Frequency of Mathematics Homework slope, β_8 INTERCEPT2, γ_{60}	-6.78 (1.56)	0.51	0.002	4.66 (1.13)	2.6	0.001
Engaged in mathematics lessons slope, β_9 INTERCEPT2, γ_{70}	3.55 (2.99)	2.25	0.283	-7.94 (1.39)	2.3	0.001

Effect was predicted to be significant at 0.05 alpha level

After adjusting for gender and home educational resources, the Student Value Mathematics (SVM) variable was the first variable introduced to the model 2 for both nations. This variable accounted for 4.9% of the overall student-level variance in eighth grade math achievement among Ghanaian students. The SVM factor's impact on math achievement was significant (γ_{10} = 22.68, $p < 0.001$). An increase of one-scale-point in SVM results in 22.68 points gain in math achievement for an eighth-grade Ghanaian student. In contrast, this variable explained 3.1% of the overall level one variance in eighth-grade Singaporean students' math performance. Statistically, the effect of the SVM factor was significant (γ_{10} = 12.63, $p < 0.001$). The results show that a one-scale-point increase in SVM makes Singaporean student 12.63 points better at math.

Students Like Learning Mathematics (SLM) was the second included in the third model for both nations. SLM accounted for 6.7% of the variance at the Ghanaian student level after adjusting for SVM. The correlation between SLM and mathematics performance was statistically significant ($\gamma20$ = 24.30, $p < 0.001$). These results suggest that a Ghanaian eighth grade student's achievement increases by 26.0 points with a one-point improvement in SLM. In comparison, the SLM predictor explained 8.7% of the student-level variation when SVM was controlled for. The correlation between SLM and math performance was statistically significant ($\gamma20$ = 22.9, $p < 0.001$). This result indicates an increase of one scale-point in an eighth-grade Singaporean student like learning mathematics increases achievement by approximately 23.00 points.

Students Confidence with Mathematics (SCM) was the third factor added to model 4 for both countries. SCM accounted for 6.6 % of the Ghanaian student-level variance adjusting for SVM and SLM. The association between math confidence and math achievement was significant (γ_{30} = 17.25, p < 0.001). This indicates that one scale-point increase in SCM increases math achievement by 17.25 points for a Ghanaian eighth grade student. On the contrary, SCM explained 14.44 % of the Singaporean student-level differences adjusting for SVM and SLM. The connection between math confidence and mathematics achievement was also significant for Singapore (γ_{30} = 28.58, p < 0.001). This result means that one scale-point increase in SCM increases mathematics achievement of a Singaporean student by 28.58 points.

Students' Educational Expectation (SEE) factor was the fourth added to model 5. This variable explained 5.6% of Ghanaian student-level variance controlling for SVM, SLM and SCM. The relationship between the index and mathematics achievement was statistically significant (γ_{40} = 10.81, p < 0.001). The result suggests that a scale-point increase in how far a Ghanaian eight grade student is expected to go in education increases achievement by 10.81 points. On the other hand, SEE contributed only 1.7% to the student-level variance for Singapore controlling for SVM, SLM and SCM. The relationship between SEE and mathematics achievement was also statistically insignificant (γ_{40} = 0.84, p > 0.184) for Singapore. The result suggests that a scale-point increase in how far a Singaporean eight grade student is expected to go in education increases mathematics achievement by approximately 1.00 point.

Students Bullied at School (SBS) was the fifth factor introduced to model 6 and this was done for both countries. The sixth model explained 2.25% of the Ghanaian student-level variance adjusting for SVM, SLM, SCM and SEE. The association between the SBS and mathematics achievement was significant (γ_{50} = 6.3, p < 0.008) for Ghana. One scale-point increase of students who are not bullied at school increases mathematics achievement by 6.3 points. In other words, students who were almost never being bullied at school out performed students who were almost always bullied at school by approximately 6.00 points within the Ghanaian context. On the contrary, SBS accounted for 1.74% of the Singaporean student-level variance controlling SVM, SLM, SCM and SEE. The connection between the SBS and mathematics achievement was also statistically significant (γ_{50} = 4.66, p < 0.001) for Singapore. One scale-point increase of students who are not bullied at school increases mathematics achievement by 4.51 points in the eighth-grade Singaporean education system. Thus, students who were almost never being bullied at school out performed students who were almost always bullied at school by approximately 5.00 points.

Frequency of Mathematics Homework (FMH) was the sixth factor added to model 7. FMH accounted for an insignificant amount of variance 0.51% when the effects of SVM, SLM, SCM and SEE were adjusted. The impact of FMH on math achievement was significant (γ_{60} = -6.78, p < 0.002). This factor was negatively related to mathematics achievement. This indicates that one scale-point increase of frequency in math homework for Ghanaian eighth grade students decrease mathematics achievement by 6.78 points. On the other hand, model 7 contributed 2.6% to the Singaporean level one variance adjusting for previous variables. The relationship between FMH and mathematics achievement was positively and statistically significant (γ_{60} = 11.41, p < 0.001). The result indicates that an increase of one scale-point increase in frequency of math homework for Singaporean eighth grade students increased mathematics achievement by 11.41 points. Engaged in Mathematics Lessons (EML) was the seventh factor added to model 7 for both countries as done previously. EML accounted for 2.5% of the Ghana student-level variance after controlling for SVM, SLM, SCM, SEE, SBS and FMH. The relationship between engaged students in learning and mathematics achievement was statistically insignificant (γ_{70} = 3.55, p < 0.283). This factor was positively related to mathematics achievement. This indicates that one scale-point increase of engaging Ghanaian students in mathematics lessons increases mathematics achievement by 3.55 points. In contrast, the results for Singapore reveals that EML contributed 2.3% of the student-level difference adjusting for SVM, SLM, SCM, SEE, SBS and FMH. The association between engaged in mathematics lessons and mathematics achievement was positively significant (γ_{70} = 7.84, p < 0.001). This means that an increase of one scale point in engaging Singaporean students in mathematics lessons increases mathematics achievement by 7.84 points.

Classroom/School-Level Model (Level 2)

Research Question Three: What is the contribution of classroom/school-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students? Example: School Discipline and Safety, Safe and Orderly Schools, Teachers' Experience, School Emphasis on Academic Success, Frequency of Test (FT), Teachers Majoring in Education and Math, Mathematics Teachers' Formal Education, Instruction to Engaged Students Learning, Teacher Condition of Service, Confidence in Teaching Math, Instruction Affected by Math Resource Shortage, School Size and Class Size. In this level 2 model, also referred to as an intercept as outcome model, fourteen classroom/school variables or covariates were included in the empty model's classroom/school equation.

Whereas the level one (student) model contained the controlled variables. Individual HLMs were developed for each of the fourteen school-level variables so that the total effect of each classroom/school-level factor on adjusted school means achievement could be determined (similar procedure to the HLMs developed for the individual student-level factors). The summary findings of the hierarchical linear models for the factors are reported in Appendix G, while a subset of the results is shown in Table 15. Table 15 also included the results of effect size (f^2) for each variable introduced into the model.

Table 15: Summaries of Level Two HLM Results for Ghana and Singapore

Fixed Effects	Ghana			Singapore		
	$\beta(SE)$	*p-value*	f^2 %	$\beta(SE)$	*p-value*	f^2 %
For INTERCEPT1, β_0 INTERCEPT2, γ_{00}	330.80 (4.65)	0.001		605.74 (4.16)	0.001	
For School Discipline and Safety, γ_{01}	31.15 (7.07)	0.001	10.5	26.37 (8.53)	0.003	6
Safe and Orderly Schools, γ_{02}	28.97 (6.71)	0.001	10.45	23.58 (8.09)	0.001	5.8
Teachers' Experience, γ_{03}	12.14 (4.97)	0.01	2.89	10.26 (4.39)	0.02	4.0
School Emphasis on Academic Success, γ_{04}	17.16 (11.08)	0.02	1	32.51 (6.97)	0.001	12.04
Frequency of Test, γ_{05}	10.56 (6.21)	0.05	1.58	25.56 (8.65)	0.004	5.5
Teachers Majoring in Education and Mathematics, γ_{06}	7.87 (3.44)	0.002	4.8	-2.31 (3.12)	0.481	1.00
Mathematics Teachers' Formal Education, γ_{07}	3.51 (7.11)	0.043	0.29	3.64 (4.3)	0.401	1.2
Instruction to Engaged Students Learning, γ_{08}	-24.24 (20.00)	0.08	0.1	6.4 (6.72)	0.256	1.3
Teacher Condition of Service, γ_{09}	4.89 (8.29)	0.471	3.3	8.9 (6.8)	0.192	2
Confidence in Teaching Mathematics, γ_{10}	-23.84 (14.62)	0.105	3.00	-2.87 (8.92)	0.748	0.8
Instruction Affected by Mathematics Resource Shortage, γ_{11}	-9.52 (13.26)	0.411		6.75 (6.53)	0.471	
Teachers Career Satisfaction, γ_{12}	-6.41 (8.38)	0.328	0.9	25.98 (7.03)	0.001	29
School Size (SS), γ_{13}	0.045 (0.02)	0.005	9	0.01 (0.01)	0.001	25
Class Size (SS), γ_{14}	-0.094 (0.11)		0.034	0.35 (0.08)	0.001	18

Effect was predicted to be significant at 0.05 alpha level

School Discipline and Safety (SDS) was the first variable introduced to the model (model 8) and this was done for both countries. The effect size in terms of variance explained was 10.5%. The influence of SDS was significant (γ_{01} = 31.15, $p < 0.001$). The result shows that Ghanaian eighth grade students from schools with scarcely any problems with discipline performed higher in average math than their counterparts from schools with moderate problems by 31.15 points. In contrast, the results for Singapore showed that SDS contributed approximately 6% to the school-level difference. The effect of SDS was also significant (γ_{01} = 26.37, $p < 0.003$) for Singapore. The result indicates that Singaporean students from schools with hardly any problems with performed higher in average math than their counterparts from schools with moderate problems by 26.37 points. The results reveal that discipline and safety is a significant strong predictor of average mathematics achievement for both countries but was more effective in contributing to math achievement in Ghana.

Model 9 was estimated by including Safe and Orderly Schools (SOS) for both nations. After adjusting for SDS, the model explained 10.45 % of the level two variance. This factor was positively and significantly related to average math achievement (γ_{02} = 28.97, $p < 0.001$). Average mathematics achievement was better in schools that were safe and orderly by 28.97 scale points. On the other hand, model 9 contributed 5.8% to the Singapore school-level difference after controlling for SDS. This factor was also positively and significantly related to averaged math achievement (γ_{02} = 23.56, $p < 0.001$) of Singaporean eighth grade students. Mean mathematics achievement was greater in Singapore schools that were safe and orderly by 23.58 scale points.

Teachers' Experience (TE) was the third variable introduced into the model (model 10). The model explained 2.89 % of the school-level variance in Ghana after adjusting for SDS and SOS. This variable was significantly and positively associated with average mathematical achievement (γ_{03} = 12.14, $p < 0.01$). This shows that the class's average maths score increases by 12.14 scale points for every year of experience the Ghanaian teacher has. In Singapore, however, the model explained 4% of the school-level variance when SDS and SOS were controlled for. This factor was positively and significantly related to averaged math performance (γ_{03} = 10.26, $p < 0.02$). This indicates that for each year of experience of the Singaporean teacher, the average math score of the class goes up by 10.26 scale-points.

School Emphasis on Academic Success (SEAS) was the fourth factor introduced into the model (model 11). The model explained approximately 1% of the Ghana school-level difference after adjusting for SDS, SOS and TE. The effect of the school emphasis on academic success was statistically significant (γ_{04} = 17.16, $p < 0.02$). This indicates that Ghanaian eighth grade students whose school emphasized on academic success performed higher scores in average mathematics achievement than their peers whose school did not emphasize on academic success by 17.16 points. Results for Singapore indicate that the model explained 12.0 % of the school-level difference after adjusting for SDS, SOS and TE. The effect of the school emphasis on academic success was also significant (γ_{04} = 32.51, $p < 0.001$). This indicates that Singaporean eighth grade students whose school emphasized on academic success performed higher scores in average mathematics achievement than their peers whose school did not emphasize on academic success by 32.51 points.

Frequency of Test (FT) was the fifth factor included in the model (model 12). The result for Ghana reveals that the model explained 1.58% of school level difference after adjusting for SDS, SOS, TE, and SEAS. The effect of the FT on academic success of the Ghanaian eighth grade students was statistically significant (γ_{05} = 10.56, $p < 0.05$). The result suggests that students whose teacher frequently gave them test out-performed students whose teacher infrequently gave them test by 10.56. The results demonstrate that for every one unit increase in test frequency there is a corresponding 10.56 points increase in average mathematics achievement. On the contrary, the result for Singapore showed this model contributed 5.5% to the school level variance after controlling for SDS, SOS, TE, and SEAS. The effect of the FT on academic success eight grade students was statistically significant (γ_{05} = 25.58, $p < 0.004$). The result suggests that students in Singapore whose teacher frequently gave them test out-performed students whose teacher infrequently gave them test by 25.56 points. This also means that for every one unit increase in test there is a corresponding 25.58 points increase in average mathematics achievement which is a substantial increase in mathematics achievement.

Sixth factor introduced to the model (13) was Teachers Majoring in Education and Mathematics (TMEM). After adjusting for SDS, SOS, TE, SEAS, and FT, the model explained 4.8% of the difference or variance at level 2. This factor was significantly linked to average math achievement of Ghanaian eighth grade students (γ_{06} = 7.87, $p < 0.002$). The results suggest that the Ghanaian grade eight students who were taught mathematics by teachers who majored in both math and math education achieved higher average mathematics than student who were taught math by teachers who did not major in both math and math education by approximately 8 points. On the other hand, result for Singapore showed that model 13 accounted for 1.00% of the school level difference after adjusting for SDS, SOS, TE, SEAS, and FT. This factor was insignificantly associated to mean math perform of Singaporean grade eight students (γ_{06} = -2.31, $p < 0.481$). The results suggest that eighth grade students who were taught math by teachers who majored in both math and math education achieved lower mean math than student who were taught math by teachers who did not major in both math and math education by approximately 2 points.

Model 14 was estimated by incorporating Math Teachers' Formal Education (MTFE) for both nations. When SDS, SOS, TE, SEAS, FT, and TMEM were controlled, the model explained a small proportion (0.29 %) of the school-level variance. This factor significantly relates with the average mathematical achievement of Ghanaian eighth graders (γ_{07} = 3.51, $p < 0.043$). The result showed that an increase of one scale point in the formal education of mathematics instructors enhances mathematics achievement by 3.51 points. After adjusting for SDS, SOS, TE, SEAS, FT, and TMEM, the model contributed 1.2% of the variance at the Singapore school level. This factor was positively but not significantly associated to the eighth-grade students' average maths achievement in Singapore (γ_{07} = 3.64, $p < 0.401$). The analysis showed that Singaporean students' math performance increase by 3.64 points for each additional scale point of formal education attained by their math teachers.

Instruction to Engage Students Learning (IESL) was the eighth factor included in the model (model 15) for both countries. The model also contributed a very negligible 0.1% to the Ghanaian school level variance after controlling for SDS, SOS, TE, SEAS, FT, TMEM and MTFE. This factor was negatively and insignificantly related to mathematics achievement of Ghanaian eight grade students ($\gamma08 = -24.24$, $p < 0.08$). The results showed that one scale-point increase in instruction to engage students' learning decreases average mathematics achievement by 24.24 points. On the contrary, the results for Singapore indicate that the model contributed 1.3% to the school level variance after controlling for SDS, SOS, TE, SEAS, FT, TMEM and MTFE. Unlike the results for Ghana, this factor was positively and insignificantly connected to the average math performance of Singaporean eighth grade students ($\gamma_{08} = 6.4$, $p < 0.256$). The results show that a one-scale-point increase in instruction to engage Singaporean students' learning increases average mathematics achievement by 6.4 points.

Teacher Condition of Service (TCS) was the ninth factor included in the model (model 16). The model explained for 3.3% of the school level differences after adjusting for SDS, SOS, TE, SEAS, FT, TMEM, MTFE and IESL. This factor was insignificantly linked to average math achievement of Ghanaian eighth grade students ($\gamma_{11} = 4.885$, $p < 0.471$). The results indicate that an increase of one scale-point in TCS increases average math achievement by approximately 5.00 points. On the contrary, the Singapore results reveal that the model accounted for approximately 2% of the school level variance after adjusting for SDS, SOS, TE, SEAS, FT, TMEM, MTFE and IESL. This factor was positively but not significantly connected to mean math performance of Singaporean eight grade students (γ_{11} = 8.9, $p < 0.105$). The results indicate that one scale-point increase in TCS increases average math attainment by approximately 9.00 points.

Confidence in Teaching Mathematics (CTM) was the tenth factor included in the model (17) for both Ghana and Singapore. This model explained approximately 3.00% of the Ghana school-level difference after accounted for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL and TCS. The link between this variable and average math performance was insignificantly negative (γ_{12} = -23.84, $p < 0.115$). Ghanaian Students' average math performance decreased 23.87 by one scale-point more in teachers' confidence in teaching math. In contrast, the model explained 0.8% of the Singapore level two variance after adjusting for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL and TCS. The association between this factor and average math performance was insignificantly negative (γ_{12} = -2.87, $p < 0.748$). Student average math attainment in Singapore decreased by 2.87 by one scale-point more in teachers' confidence in teaching math.

Instruction Affected by Mathematics Resource Shortage (IAMSR) was the eleventh factor added to model (18). The association between this variable and mean math achievement was also insignificantly negative (γ_{13} = -9.522, $p > 0.411$) for Ghana. The connection between this variable and the mean mathematical achievement of Ghanaian students was equally insignificantly negative (13 = -9.522, $p > 0.411$). The findings revealed that the mean math achievement of Ghanaian students declined by 9.52 percentage points for each additional scale point of instruction affected by resource shortage. In contrast, there was a strong positive correlation between this variable and mean math performance (γ_{12} = 6.75, $p < 0.0471$) for Singapore. Singaporean students whose instruction was not affected by mathematics resource shortage performed better in mathematics achievement than their counterpart whose instruction was affected by mathematics resource shortage.

Model 19 was estimated by adding Teachers Career Satisfaction (TCS) factor. This was done for the two countries. Results for Ghana showed that this model explained 0.9% of level two variances after adjusting for previous factors. The influence of this factor on mean math achievement was not significant (γ_{13} = -6.41, $p < 0.328$). The results also indicate that Ghanaian students' average mathematics achievement lessened by 6.41 by one scale-point rise in teacher career satisfaction. In contrast, the results for Singapore indicates that the model contributed approximately 29% to the school level differences after controlling for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL, TCS and IAMSR. The impact of this variable on average math achievement was significant (γ_{13} = 25.89, $p < 0.001$). The results indicate that an eighth-grade Singaporean student average mathematics achievement increases by 25.89 by one scale-point increase in teacher career satisfaction.

School Size (SZ) and Class Size (CS) were the final two variables included to models 15 and 16 of each country. After adjusting for prior variables, the school size factor explained for 9.0% of the variance at the school level in Ghana. The correlation between students' mathematical achievement and school size was statistically significant and positive (γ_{13} = 0.045, $p < 0.005$). Average mathematics achievement increased by approximately 0.05 in schools with one scale-point increase in SZ. Unlike Ghana, the results for Singapore showed that the school size factor accounted for 25% of the level two variance after adjusting for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL, TCS, IAMSR and TCS. The relationship between SZ and average mathematics achievement was statistically significantly positive (γ_{13} = 0.01, $p < 0.001$). Average mathematics achievement increased by approximately 0.01 in schools with one scale-point increase in school size.

Class Size explained 0.034 % of the school level difference of math performance after controlling for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL, TCS, IAMSR, TCS and SZ for. The association between CZ and average mathematics achievement was insignificantly negative (γ_{13} = -0.0944, $p < 0.0273$). The result indicates that average mathematics achievement decreased by approximately 0.1 with one scale-point increase in class size. In contrast, results for Singapore reveals that Class Size explained 18.00 % of the school level variance of mathematics achievement after adjusting for SDS, SOS, TE, SEAS, FT, TMEM, MTFE, IESL, TCS, IAMSR, TCS and school size. The link between class size and average math performance was also positive and significant (γ_{13} = 0.35, $p < 0.001$) for Singapore. The result indicates that average math achievement increased by approximately 0.4 with one scale-point increase in class size.

The full model (Ghana and Singapore)

Even though the drive of this investigation was to analyse the contribution and effect of each predictor on math attainment at both the student and classroom/school levels, it was crucial to determine the effects of both student and classroom/school factors simultaneously. This led to the whole model's estimation. Table 4 in Appendix B provides the significance levels and coefficients for the fourteen classroom/school predictors and seven student-level predictors for the complete model. The results of the full model demonstrated that the same six significant student-level predictors of math achievement in Ghana were also significant in connection with the full model. In contrast, the results for the Singaporean full model demonstrated that out of the six predictors that were significant for the school level model, five were significant. That is, SVM was not significant in the full model for Singapore.

In Ghana, the complete model explained 17.30% of the variance at the student level and 53.9% of the variance at the school level in eighth grade mathematics achievement. This indicates that 17.3% of the 59.29% of student-level variance that needed to be explained was explained by the student-level factors included in this study. 53.9% of the 40.71% of variance required to be explained at the classroom/school level was explained by the factors listed at this level. This indicates that school-level variables explained somewhat more than half of the school-level variance. In contrast, the comprehensive model for Singapore explained 16.10% of the student variable and 47.57% of the level two variance in eighth grade mathematics achievement. This shows that the student-level factors considered in this analysis explain 16.10 % of the 56.51 % at student-level that needed to be explained. The factors included at this level explained 47.57 % of the 43.49 % of variance that needed to be explained at the classroom/school level. The results indicate that school-level factors explained somewhat less than half of the school-level variance.

In both countries, the differences in eighth-grade math achievement were greater at the school level than at the individual student level. Table 16 displays the results of the variance explained by the full model.

Table 16: Explained Proportion of Variance at Both Students and School Level for Ghana and Singapore

	Ghana			Singapore		
level	Initial Variance	Final Variance	Percent Variance Explained	Initial Variance	Final Variance	Percent Variance Explained
Student	4323.79	3576.394	17.3%	3915.81	3285.5	16.10%
Classroom/School	2968.87	1367.74	53.9%	3014.19	1580.13	47.57%

Variance Explained

According to Lorah (2018), total variance for a hierarchical model is more intricate than for a single model like a multilevel regression model. A formula for regarding hierarchical models is offered by Snijders and Bosker (2011): $R^2 = 1 - \frac{\sigma_F^2 + \tau_F^2}{\sigma_E^2 + \tau_E^2}$. Where σ_F^2 represent the level-one random error variance for the complete model; τ_F^2 represents the level two random error variance for the full model; and σ_E^2 represents the level – one random error variance for the null model; τ_E^2 represent the level-two random error variance for the empty or null model (Lorah, 2018).

In this current study, the variance parts based on the null model and the complete model were calculated and used to compute $R^2$of models for both countries. $R^2 =$ 0.32 and 0.30 were obtained for Ghana and Singapore models respectively. The R^2 can be interpreted as the part of variance in mathematics achievement accounted for by all the variables at both levels (Lorah, 2018).

The Effect Size for the Overall Model for Both Countries

The effect size measure linked to variance accounted for the overall model is f^2 that can be calculated as: $f^2 = \frac{R^2}{1-R^2}$ (Cohen, 1992). In the current study, $f^2 = 0.51$ and $f^2 = 0.43$ for the overall models (Ghana and Singapore) indicating that all the 21 variables selected for investigation at both levels explain 51% and 43% of variance in math achievement relative to the unexplained variance in math achievement of the Ghanaian and Singaporean students respectively. Guidelines for interpretation of f^2 indicating that 0.02 is a small effect, 0.15 is a medium effect, and 0.35 is a large effect (Cohen, 1992), the present effect of models for both countries are large.

Summaries of Findings from the Student's Level Analysis

1. Among the seven students level predictors, (SVM, SLM, SCM, SEE, SBS, FMH and IESL), SCM and SLM influence student's mathematics achievements the most for Singapore and Ghana respectively. This is indicated by the value of the coefficients of SCM and SLM for the two countries.
2. Ghanaian students had greater positive slopes in SVM, SLM, SEE, and SBS compared to their counterparts.
3. An independent variable with a significant random influence suggests that the link between the factor and mathematics achievement varies significantly throughout the school populations. For the seven predictors SVM, SLM, SCM, SEE, SBS, FMH and IESL, they all have significant random effect among the two countries. This means that there exist

differences among schools in the two countries. This finding confirms the ICC results of this study. The ICC results for the two countries showed that there were considerable variances amongst schools.

4. Even though FHM was a significant predictor of math performance for both countries, it was negatively related to math achievement for Ghanaian students. Singapore as top-performer in TIMSS 2011 mathematics achievement have stronger positive slope in this predictor.
5. The slopes of IESL and SEE factors of Ghana and Singapore respectively are less predictive on mathematics achievement. The less predictiveness of these factors on mathematics achievement is reflected in the values of the slopes.
6. The intercept values provide insight into the effectiveness of schools. The bigger the value of the intercept, the more effective the country's educational system (Ker, 2016). The intercept values, which are 330.80 and 605.75 for Ghanaian and Singaporean schools, respectively, disclose or reflect the effectiveness.

Discussions

Singaporean and Ghanaian students have a considerable success or performance disparity in mathematics, according to TIMSS reports. In this comparative study, a conceptual framework and an integrated model were utilised to investigate the contribution of multilevel factors on mathematics achievement in these two nations. This section discusses the study's findings. This section begins with a description of the HLM results in connection to the study questions, relevant literature, and theory. Finally, the chapter concludes with a review of the study's key findings. This study's findings agree with the modified "Input-Process-Output" conceptual model, which drove the selection of variables. The findings confirmed the notion that a student's learning and performance are affected by his or her background, the teacher or classroom, and the school (Ker, 2016).

Discussion of the Findings in Relation to the Research Questions

In this section, the three research questions that guided the study are revisited.

Research question 1: Which of the two levels (student and classroom/school) has the most impact on the mathematics achievement of eighth grade Ghanaian and Singaporean students?

Student achievement was modelled as a function of student and classroom/school factors in the present study. When performance differences were broken down into differences within schools and differences between schools, most of the differences in both countries were within schools. Students' level differences accounted for a bigger amount of the variance in the mathematical achievement of eighth-grade students in Ghana and Singapore (59.58 % and 56.60 %, respectively). The findings show that the learning of eighth-grade mathematics education in Singapore and Ghana is greatly and largely influenced by student-level characteristics. Consequently, student-level factors make a large difference between the two nations in eighth-grade mathematics success (Mohammedpour, 2012). This result confirms the results of other research studies (Nyatsikor, 2019; Butakor, 2015; Mohammedpour & Ghafar, 2014; Chepete, 2008; Lamb & Fullarton, 2002; O'Dwyer, 2000). Mohammedpour and Ghafar (2014), for instance, found that mathematics achievement in 90% of TIMSS participating nations, including

Ghana and Singapore, was substantially determined by student-level characteristics. These findings emphasise the increased importance of student-level variables on eighth graders' mathematics achievement. These findings have implications for policymakers, school administrators, teachers, and students. Thus, the findings provide information to school leaders and policy makers by being aware of the specific level-factors to be considered when making policies in terms of student achievement in mathematics. For example, student-level factors, which include but are not limited to SVM, SLM, and SCM, are malleable and enhanced by classroom practise. Moreover, students spend more time at school than anywhere else outside the house. This suggests that schools have considerable influence over these aspects. Through good teaching and learning events and practises, schools may build, shape, and change these characteristics in students. For instance, teachers can aid students' SCM by offering assignments based on their capacities, grading assignments with instructional feedback, and recognising their classroom success (Mohammedpour & Ghafar, 2014). Since Singapore is a high performer in the TIMSS assessment across the years of participation and Ghana is a low performer, Ghana can take a cue from this finding and focus on the development of students' characteristics that can be influenced at both the school and the classroom levels to enhance high level mathematics achievement at the eight-grade level.

Furthermore, the results showed that classroom/school-level variances explained 40.42 % variance in eighth-grade mathematics achievement among Ghanaian students. Similarly, a comparable amount of the difference in math performance in Singapore was linked to level two differences (43.40 %).

These results imply that schools in both countries affect student achievement differently. The finding is also consistent with prior findings (Chepete, 2008; Butakor, 2015; Nyatsikor, 2019; Lamb & Fullarton, 2002; O'Dwyer, 2000; Mohammedpour, 2012; Ghagar, Othman & Mohammedpour, 2011). Anderson (1991) intimated that schools' efficacy depends largely on teacher characteristics, which are considered together with school characteristics in the current study. Teachers have greater influence over innovation and change than any other profession, even in the most highly centralised education systems, which is the case of both countries considered in this current study.

Consequently, classroom activities may explain for this variation in student achievement. Educational researchers have debated for a very long time the impact of schools on students' academic ability. Early research on school efficacy, such as those conducted by Coleman (1966) and Jencks (1972), demonstrated that the influence of school on students' academic achievement are very minimal compared to the effects of their traits and family background. After Colemans' (1966) research, other studies (Strayhorn, 2010; Chepete, 2008; Wang, Liu, & Leung, 2022; Fullarton, 2004) have been conducted to evaluate the impact of school on students' mathematical achievement. A significant fraction of the total variation in mathematics achievement was shown to be attributable to school-level variances. In this study, the fraction of variance ascribed to school-level differences exceeds the range observed in recent investigations. This study's findings add to the evidence from earlier research that schools affect students' academic achievement. This study has demonstrated that, even though schools affect students' mathematics achievement, student-level factors or traits have a stronger influence on math achievement. In other words, the eighth-grade mathematics achievement is mostly determined by the student-level variables.

Research question 2: What is the contribution of selected student-level factors? For example: Students' Value of Mathematics**,** Students' Like Learning Mathematics**,** Students' Confidence with Mathematics**,** Students' Educational Expectations, Students Bullied at School, Frequency of Mathematics Homework, and Engaged in Mathematics Lesson mathematics achievement of eight grade Ghanaian and Singaporean students?

The Contribution of Student-Level Factors to Mathematics Achievement

At the student level, SVM, SLM, and SCM accounted for 18.20 % variance in eighth-grade Ghanaian students' mathematics achievement. In comparison, these three variables accounted for 26.20 % variance in Singaporean students' mathematics achievement at level one. This suggests that these variables have a greater impact on the mathematical achievement of Singaporean students than Ghanaian students. The findings of both nations are consistent with earlier research (Howie, 2003; Martin et al., 2000; Chepete, 2008; Mohammedpour, 2012; Ghagar et al., 2011; Butakor, 2015; Ker, 2016; Topcu et al., 2016). All three attitudinal characteristics were positive and significant contributors to mathematical achievement, apart from SVM, which was not a significant contributor to Singaporean students' mathematics success. This implies that as students' attitudes toward mathematics improve, so in addition will their mathematical performance, and vice versa (Topcu et al., 2016). At this point, the researcher can assert that, independent of a country's qualities, attitudes toward mathematics appear to be a crucial component that significantly and substantially influences students' mathematical achievement. Therefore, if we wish to help students perform better in mathematics, we must first alter their attitudes toward the subject. In addition, the results indicate that attitudinal variables (SVM, SLM, and SCM) explained greater proportion of variance than other level one predictors in this study.

These results are also consistent with some past research (Wilkins, 2004; Ma & Kishor, 1997; Howie, 2003; Papanastasiou, 2000). Since attitude factors can be generated, developed, and reformed during the teaching and learning process, these findings have significant implications for educational policymakers. As a result, Ghanaian educational policymakers might use the results of this study to develop policies aimed at enhancing these factors, as attitudes had a greater impact on Singaporean students' accomplishment in math.

The impact of SCM on academic performance varied between Ghanaian and Singaporean students. Singaporeans possessed a more effective and robust mathematics self-concept than Ghanaians in terms of variance explained and the link between this variable and mathematical achievement. Thus, among the student-level determinants, SCM considerably contributed the most to the Singaporean students' mathematical achievement. This finding is largely consistent with earlier research indicating that students' self-confidence or self-concept of mathematical competence had the greatest influence on mathematics accomplishment in the United States, Russia, South Africa, Singapore, and Malaysia (Sevgi, 2021; You, Kim, Lim, & Dang, 2021; Ker, 2016; Chen, 2013; Ghagar et al., 2011). Specifically, Chan (2013) discovered that among the six important indicators at the student level, student confidence in learning mathematics was the strongest in Singapore. Similarly, Sevgi (2021) discovered that self-confidence in learning mathematics was the most influential attitude variable on mathematics achievement. In contrast, this factor was the third most effective and strongest positive significant contributor to Ghanaian students' mathematics achievement. The findings from Ghana confirm the positive significant predictability of this factor in mathematics achievement regardless of a country's characteristics.

The impact of SLM on mathematics varied between eighth-grade students in Ghana and Singapore. According to the results, SLM was the most influential and significant factor in eighth graders' mathematical achievement in Ghana. This observation is consistent with earlier findings (Frempong, 2010; Butakor, 2015; Butakor, 2016; MoE, 2004). For example, Frempong (2010) found that boys who wanted to do well in school, liked math, and mentioned they were confident in their capacity to learn math did better than their counterparts. This result agrees with the Ministry of Education's (MoE) report from 2004, which indicated that students do better in math if they have confident in their math skills and have high educational goals. Recent research conducted by Butakor (2015) verified this finding. He discovered that students who enjoyed learning mathematics made positive contributions to their math achievement.

In contrast, this variable was the second most influential contributor to the mathematical achievement of Singaporean students. It is not surprising that the variable was a better predictor of math achievement in Ghana than in Singapore. Literature indicates that countries that performed well on the TIMSS tests had a greater proportion of students who rated a relatively low aptitude for maths. In contrast, less successful nations had more students who exhibited an interest in mathematics (Mullis et al., 2004; Mullis et al., 2020; Mullis et al., 2016; Shen & Pedulla, 2000). The study indicated that regardless of a country's qualities and other circumstances, this variable is a significant contributor to students' mathematics achievement. The study's findings have consequences for teachers, school administrators, and policymakers who seek to create a conducive learning environment to boost students' interest in math and sense of self-efficacy, hence improving their math performance.

The impact of SVM on mathematics also varied between eighth-grade students from Ghana and Singapore. The findings found that eighth-grade students in Ghana value mathematics more than their peers in Singapore. The results of this study's student-level model and full model suggested that SVM failed to accurately predict the mathematical achievement of Singaporean students. This finding supports earlier research (Ker, 2017, 2016; Harmouch, et al., 2017). Ker (2017) discovered that SVM has little impact on Singaporean and American students. However, it was anticipated that Singaporean students' value of mathematics would considerably contribute to their average mathematical performance. According to the research, students from East South-Asia, of which Singapore is a part, have a lower aptitude for mathematics but rank among the best scorers on a few international large-scale examinations (e.g., TIMSS, PISA) (You et al., 2021). Mohammedpour (2012), for instance, found that despite the great performance of Singaporean students on TIMSS assessments, the value of mathematics among Singaporeans is low compared to the global average. According to Ker (2017), this may occur due to the cultural background of Singaporean students, who are trained to have a moderate opinion of their own abilities and beliefs. Leung (2005) stated that self-concept and valuation of mathematics are influenced by additional elements, namely cultural features. Despite this, several studies have demonstrated that SVA is a significant contributor to eighth graders' mathematical achievement (Mullis et al., 2020; Mullis et al., 2016, Mullis et al., 2009; Topcu et al., 2016; Butakor, 2016; House, 2003). For instance, Mullis et al. (2020) discovered a correlation between a higher average math score and a higher math value.

Students' educational expectations also differed for Ghanaian and Singaporean eighth grade students. The Ghanaian students' educational expectations were higher in terms of the contribution to mathematics achievement than their Singaporean counterparts were. The variables were not significant in terms of its contribution to the Singaporean students. The Singaporean finding is consistent with some previous studies. For example, Mohammedpour found that Singaporean students' educational aspirations were not a significant contributor to the mathematics achievement of students. However, literature suggests that having high academic expectations is a major factor that has consistently been found to have a direct and mediating effect on academic achievement (Buchmann & Dalton, 2002; Pinquart, & Ebeling, 2020; Bui, 2007), and accounts for the high achievement pattern and often exceedingly high educational performance of Asian students compared to white, African-American, and Hispanic students (Sue & Okazaki, 1990). On the other hand, the variable was related positively to mathematics achievement in both countries. This means that in both nations, students' desire to climb high in terms of educational aspiration has a corresponding effect on their mathematics achievement. This finding is not surprising because most tertiary institutions (e.g., colleges of education, technical universities, and traditional universities) in Ghana and elsewhere require a pass in mathematics for admission to all courses.

Thus, students who wish to progress to these institutions must give serious attention to mathematics. These findings resonate with previous findings. For instance, Frempong (2010) found a significant contribution of students' educational aspirations to the mathematics achievement of Ghanaian either-grade students. He concludes that the desire to acquire a university education is a driving force for successful learning. Similarly, Butakor (2015) added that Ghanaian students with higher educational aspirations obtained higher scores than students with lower educational aspirations. Comparative global studies, for example, show that eighth-grade students who stated higher educational aspirations had higher mean math achievement than those at the lower level. Specifically, those anticipating a postgraduate degree showed much greater average success than those anticipating only upper secondary education. Nonetheless, several studies have demonstrated a negative impact on mathematical achievement (Hammouri, 2004).

The frequency of mathematics homework contributed significantly and positively to the mathematical achievement of Singaporean eighth graders, after attitude characteristics. Similarly, the effect of this factor on the eighth-grade mathematics achievement of Ghanaian students was significant but inversely correlated with mathematical achievement. Some studies have found that homework has a positive impact on student achievement, while others have found that it has a negative impact (Dettmers, Trautwein, & Lüdtke, 2009; Boddison, 2015).

Literature indicates that this variable has a mixed effect on mathematics achievement, which is supported by the results of the current study. Nevertheless, several prior studies (Dettmers, Trautwein, Lüdtke, Kunter, & Baumert, 2010; Fernández-Alonso, Suárez-lvarez & Muiz, 2015; Areepattamanil & Kaur, 2013; Cheema & Sheridan, 2015; Ladson, 2012; Pelletier, 2005; Riley, 2007) have discovered a significant and positive effect of homework frequency on mathematics achievement. Despite the negative effect of homework on mathematics accomplishment found by certain studies, including the present study, other studies have demonstrated that homework can also increase students' academic success in addition to their math qualifications (Bembenutty, 2011; Ramdass & Zimmerman, 2011; Rudman, 2014; Stoeger and Ziegler, 2008; Xu, 2005; Warton, 2001). The frequency of homework was a better predictor of eighth-grade math performance among Singaporean students, according to the findings of this study. For Ghanaian students to perform better in mathematics, policymakers, instructors, and school administrators may wish to reconsider the homework policy.

The HLM results indicate that students being bullied at school significantly contribute to mathematics achievement in both countries. This means that students who were almost bullied at school performed differently than those who were almost not bullied. These findings of the current study resonate with current literature (Lai, Ye, & Chang, 2008; Mullis et al., 2012; Topcu et al., 2016; Yalcin, Demirtasli, Dibek, & Yavuz, 2017). These studies indicated that students being bullied at school affected students' mathematics achievement. For example, Topcu et al. (2016) found in their study that students not being bullied at school significantly predicted mathematics achievement. Bullying at school is a very sensitive issue that should be looked at holistically. This is because of the role it plays in the overall academic achievement of students. For instance, Mullis et al. (2012) found that students who attended schools with disorderly surroundings reported more instances of bullying and significantly worse achievement than their peers who attended schools with safe and orderly environments. Negative school impression and bullying may have an adverse effect on mathematical proficiency of students. When students experience bullying and have a negative school perception, these situations may have a negative impact on their emotional development, and as a result, their mathematical performance may suffer (Sharp, 1995). Additionally, bullying may result in psychological, social, or academic issues (Woods & Wolke, 2004). If we expect Ghanaian students to accomplish at a high level, we must offer safe and stable surroundings in which they can concentrate and improve their mathematics grades. In Ghana, school officials, teachers, counsellors, and parents should be proactive in planning anti-bullying and perception-altering methods for students. For example, school administrations and psychologists might organise instructional programmes for students and their parents to raise awareness of bullying. In these activities, students and their families could learn about the definition of bullying, its prevention, and its effects. The Ministry of Education in Ghana could also learn from the Ministry of Education in Singapore, which is perusing the policy of No-Tolerance Policy for Bullying in Singapore, which has reduced bullying in schools.

The results of this study demonstrated that students who are actively engaged in mathematics lessons contribute significantly and positively to mathematics performance in both countries. The correlation between average mathematical achievement and student engagement was direct. Thus, the better engaged students were in their mathematical instruction, the greater their average maths achievement. Given that students acquire much of their mathematics knowledge in the classroom, it is logical to assume that the instruction they get has a significant impact on their accomplishment (Leung, 2005). Previous findings are consistent with those of the present investigation (Sanders, et al., 1997; Daniel House & Telese, 2016). For instance, Fung, Chang, and Gaowei (2018) argued in their study that students with greater levels of academic (mathematics) accomplishment were more engaged. Nonetheless, the variable had a different impact on Ghanaian and Singaporean students. The results suggested that eighth-grade Singaporean students were more engaged in maths lessons than their peers were. The differential effect of this factor in favour of the Singaporean students might be related to the cultural values held by the teachers who are the developers and presenters of mathematics lessons. According to Leung (2005), the highly engaging mathematics lessons in Asian classrooms are a result of teacher competence not only in the subject matter of mathematics but also in selecting an appropriate pedagogy. This may be a significant factor in East Asian students' high achievement in mathematics. It is intriguing to consider whether this higher degree of proficiency is connected to the Asian concept of the "scholar instructor" (Leung, 2005).

In traditional Chinese culture, which some researchers (Watkins, & Biggs, 1996) refer to as the "Confucian Heritage Culture," the teacher is viewed as a subject area expert. Certainly, teaching abilities are equally important, but teachers will not be recognised if they lack expertise in the subject, they teach. This idea of the scholar-teacher may inspire Asian educators to pursue subject matter and pedagogical expertise at a high level. Cultural factors, which "touch on values as fundamental as the nature of mathematics, the nature of teaching and learning, and the understanding of the role of the teacher" (Leung, 2001, p. 46), may be the key to comprehending classroom practise and explaining why East Asian students perform better in school (Leung, 2005).

The Contribution of Classroom/School-level Factors to Mathematics Achievement

Research Question Three: What is the contribution of selected classroom/school-level factors to mathematics achievement of eighth grade Ghanaian and Singaporean students? For example: School Discipline and Safety, Safe and Orderly Schools, Teachers' Experience, School Emphasis on Academic Success, Frequency of Test (FT), Teachers Majoring in Education and Math, Mathematics Teachers' Formal Education, Instruction to Engaged Students' Learning, Teacher Condition of Service, Confidence in Teaching Math, Instruction Affected by Math Resource Shortage, School Size and Class Size.

The fourteen classroom/school characteristics chosen for investigation regarding their contribution to the math achievement of grade eight students accounted for 52 % variance of Ghanaian students at the classroom/school level. In comparison, these variables explained 95% of the total variance of Singaporean students at classroom/school level. The results at the classroom/ school level demonstrated that school discipline and safety, as perceived by school principals, were positively and significantly related to the grade eight mathematics achievements of students in both nations. Even though this variable was positively and significantly connected with mathematics achievement in both nations, it had a different impact on students from Ghana and Singapore. For instance, this variable had the greatest impact on the academic achievement of Ghanaian students. However, the results indicate that it was the second most impactful influence on the achievement of Singaporean students. This factor was more successful in explaining the total school variance for Ghanaian students than for Singaporean students. This is because the variance explained by this variable in Ghana (10 %) was greater than in Singapore (5 %). A study by Walberg (1984) demonstrated that IQ explains only 7 % of the variance in academic performance among students. However, 30% of the variance might be attributed to the learning environment.

These findings are consistent with those of prior research examining the association between school discipline and safety (school environment) and mathematics (Sevgi, 2021; Ersan & Rodriguez, 2020; Ghagar et al., 2011; Chepete, 2008; Lubienski et al., 2008; Mohammedpour, 2012; Butakor, 2015; Butakor, 2016). In their study, Ghagar et al. (2011) found that school atmosphere, as evaluated by school heads, was the most powerful variable for both nations (Malaysia and Singapore). Similarly, Butakor discovered that Ghanaian students whose principal and instructors had a positive impression of their school did better than those whose principal and teachers had a negative perception of their school. In addition, Sevgi (2021) discovered a significant relationship between a principal's sense of school safety and mathematical achievement. Not only is this variable a strong and significant predictor of mathematics achievement, but it also predicts scientific achievement. Among the three school-level variables evaluated in Bear et al.’ (2015) study, only school climate was a significant predictor of science achievement. According to Yang, the finding support Ker's (2016) contention that a positive learning environment is more important than science materials.

The establishment of a positive and supportive learning environment may have a greater impact on student science achievement than the background characteristics of teachers. According to Van Horn (2003), school environment is a crucial component of a successful school that can accurately predict student mathematical proficiency. Literature demonstrated that schools with fewer rates of violence, larceny, and abusive language created a better learning environment for students (Chepete, 2008). According to Chepete, (2008), students in less safe environments had less time to focus on academic work because they were worried about victimisation; additionally, some of the teaching time may be diverted to addressing disciplinary issues, whereas in schools with positive climates, there would be fewer incidents that disrupted the academic process.

Thus, the researcher may assert that, regardless of the country's peculiarities, school discipline and safety is a crucial element that adds significantly and substantially to students' mathematical achievement. These discoveries have consequences for educators and policymakers. Educators and administrators are primarily responsible for ensuring school safety and a secure learning environment. These parties must be aware that a disordered environment has a negative impact on the academic attainment of students of all levels. A favourable school climate improves students' attitudes toward mathematics and, indirectly, their achievement in mathematics. Students should attend school without anxiety and worry. Therefore, it is suggested that eighth-grade teachers and principals in Ghana develop a disciplined and secure learning environment for students in order to improve mathematics proficiency. Therefore, if we wish to boost students' mathematics achievement, it would be a good idea to promote a positive and favourable school climate, regardless of country-specific characteristics.

The Safe and Orderly Schools factor was included in the analysis to determine the extent to which school safety and order may influence the mathematical achievement of students. The results demonstrated that the variable contributes positively and significantly to mathematics achievement in both nations. The positive effect of this variable to mathematics success in this study implies that schools in both nations that were safe and well-maintained boosted their students' average mathematical achievement. These findings are consistent with prior research examining the effect of safe and orderly schools on students' mathematics performance (Martin & Mullis, 2013; Mullis et al., 2012; Milam, et al., 2010). For instance, Mullis et al. (2012) discovered that the safer the school, the greater the average mathematical achievement of the students. In terms of contribution and variance explained at the school level, the variable had a differential effect on the mathematics achievement of students. For instance, the variable was the second most impactful variable on the achievement of Ghanaian students. Nonetheless, the results indicated that it was the fourth most relevant factor in determining the academic success of Singaporean students. Regarding the explained total school variation, this factor was more effective for Ghanaian students than Singaporean students. This indicates that the impact of this variable to the differences or variation in student success between the two nations was greater for eighth-grade students in Ghana than in Singapore. This is because the proportion of variance explained by this variable in Ghana (10.45 %) was greater than in Singapore (5.8 %).

The results indicate that teaching experience has a significant and positive association with student math accomplishment in both countries. Students in eighth grade who were taught by more experienced instructors (in terms of length of service) had, on average, greater test scores than those who were taught by less experienced teachers. These results are consistent with previous research that examined the effect of teaching experience on the mathematical achievement of students (Nyatsikor, 2019; Mohammedpour, 2012; Chepete, 2008; Mullis et al., 2012; Hanushek, 1996). For example, Nyatsikor (2019) discovered a statistically significant link between teaching experience and mathematical achievement. In addition, Mullis et al. (2012) found that the average mathematical achievement of students whose teachers had at least 20 years of experience was greater than that of students whose teachers had between 10 and 20 years of experience or those with even less experience. More experienced educators focus on the most effective method for teaching particular subjects to students whose talents, prior knowledge, and backgrounds vary (Teddlie & Springfield, 1993). According to Stronge

(2007), teaching is a dynamic process in which inexperienced teachers are unable to adhere to the plan, whereas experienced teachers can do so with ease. All these tactics are embraced and modified by more experienced educators in order to improve student accomplishment. Nonetheless, some earlier research found no correlation between teaching experience and students' mathematical performance (Butakor, 2015; Xin, Xu, & Tatsuoka, 2004). For example, Butakor found no correlation between teaching experience and mathematics achievement. These results mirror the contradictory findings in the literature concerning the link between teaching experience and math achievement. The results also revealed that the variable (teaching experience) had varied effects on the math achievement of students in both nations. In terms of predicting mathematical achievement, the factor was more accurate in Singapore than in Ghana. This factor was more successful in explaining the overall school variance for Singaporean students than for Ghanaian students. This shows that this variable had a considerable impact in Singapore in terms of its contribution to mathematics achievement.

This also means that in Singaporean schools, eighth grade is taught by more experienced instructors. This research has consequences for school administrators and policymakers. When assigning instructors to different courses or grades, the school principal should consider sending experienced teachers to eighth grade classes. This may increase the mathematical achievement of these students. It is advised that policymakers and school administrators give all teachers more opportunities to advance their professional skills and expertise. This would increase the relevance of the teaching experience to the academic success of students.

The School Emphasis on Academic Success factor was the most influential positive factor on the mean mathematics achievement of Singaporean schools, whereas it was the third most influential positive factor on the score of Ghanaian schools. Teachers' and schools' expectations of academic performance strongly and positively impact mathematics achievement in different nations (Ker, 2016; Mullis et al., 2012; Demirtasli, Dibek, & Yavuz, 2017), as supported by these findings. Across all nations participating in TIMSS 2011, including Ghana and Singapore, correlations between school emphasis on academic success and student performance on mathematical achievement tests have been identified as significant (Mullis et al., 2020; Mullis et al., 2012; Nilsen, & Gustafsson, 2014). Students who do better in school also go to a school that puts an emphasis on academic success. This can be seen in how well teachers understand and implement the school's curriculum, how much they care about student success, how much their parents care about their success, and how much they want to do well in school (Mullis et al., 2012). This factor was more successful in explaining the overall school variance for Singaporean students than for Ghanaian students. This is since Ghana's (1 %) percentage variance explained by this variable was less than Singapore's (12.04 %). This suggests that, in terms of its contribution to math achievement in Singapore, this variable contributed significantly. This is something that makes the societies of the top-performing TIMSS East Asian countries, like Hong Kong, Korea, Japan, and Chinese Taipei, stand out (Ker, 2016). The cultures of East Asian nations in general, as well as instructors, have high academic standards for students. The presence of high instructor expectations for student accomplishment is critical to effective learning.

Students can make significant increases in their academic performance if schools set high goals, communicate effectively with them, provide demanding learning activities, and listen to student input (Ker, 2016). This study was able to establish that school concentration on the academic success of students considerably adds to their mathematics achievement. Scherer and Nilsen (2016) discovered that when schools prioritise academic achievement, students are more motivated and perform better in the classroom.

Principally, these findings have consequences for school administrators and teachers. This is because it is primarily the duty of school principals and instructors to guarantee that a significant emphasis is placed on academic performance among students. Even if the strong emphasis on academic achievement of students in Singaporean schools by both teachers and school principals has some cultural interaction, low-performing countries such as Ghana can learn by paying close attention to the strong emphasis on academic success.

The goal of introducing the Test Frequency factor in the analysis was to determine its impact on eighth-grade mathematics achievement as measured by TIMSS. The frequency of tests had a significant effect on the mathematical achievement of students in both Ghana and Singapore. This indicates that in both nations, students whose teachers offered tests frequently performed better than those whose teachers did not. It is important to note that the variable had a differential effect on the mathematical achievement of students in both countries. The variable was more successful in explaining the overall school variance for Singaporean students than Ghanaian students.

Similarly, the variable had a greater impact on the mathematical abilities of Singaporean students than those of Ghanaian students.

In terms of statistically significant contributions to students' mathematics performance, the results for both nations reflect contradictory findings in the literature (Butakor, 2015; Guven, 2017; Kuku & Alade, 2017; Mullis et al., 2012; Khalaf & Hanna, 1992; Shirvani, 2009; Gholami & Moghaddam, 2013). For instance, Butakor (2015) discovered that the frequency of testing did not significantly influence Ghanaian students' mathematical achievement. Similarly, Guven (2017) found that testing frequency had no significant effect on the mathematical achievement of Singaporean students, even though there was a disparity in students' mean achievement. Some studies indicate that infrequent classroom testing may be preferable to frequent testing for increasing mathematical achievement (Zgraggen, 2009). Nonetheless, several researches have supported the contention that frequent testing promotes student achievement, which is the conclusion of the present study based on its findings. For instance, Khalaf and Hanna (1992) discovered that students who were tested frequently outperformed those who were assessed less frequently. In a similar vein, Kuku and Alade (2017) discovered considerable variation in the mean scores of students' achievement in mathematics and study habits because of varying test frequency. Despite these contradictory findings, learning theories suggest frequent testing as an effective method for enhancing student learning. Frequent testing serves as both a retrieval exercise and an active learning technique (Guven, 2017; Francisco, 2014; Karpicke & Grimaldi, 2012).

Frequent testing helps learners construct their own learning by activating their prior knowledge (Pelech, 2016).

Teachers Majoring in Education and Mathematics factor was included in the analysis to investigate its connection to mathematics success. According to the findings of the study, the variable had the opposite influence on the mathematical achievement of students in both countries. In the Ghanaian context, the variable was found to be positively and significantly connected to mathematics achievement. This result is consistent with research examining the relationship between teacher major and mathematics achievement (Mullis et al. 2012; Wayne & Youngs, 2003). For instance, Wayne and Young (2003) discovered that, at least in high school, students learn more mathematics when their teachers had additional mathematics degrees or coursework. In contrast, the variable was adversely and insignificantly related with Singaporean students' mathematics achievement. Concerning Singapore, this discovery is somewhat alarming. It was anticipated that the variable will have a positive and statistically significant impact on the mathematics achievement of high-achieving Singaporean students on the TIMSS examination. The negative connection between the variable and mathematics achievement indicates that when Singaporean instructors major in mathematics and education, their students' mathematics achievement drops. In addition, this factor's negligible impact on the mathematical achievement of Singaporean students renders it irrelevant to the mathematics achievement of these students. One of the possible explanations to this finding is the lack of variability in the responses to this variable (Chepete, 2008). TIMSS 2011 international results indicate that 32% of “students were taught by teachers with a major in mathematics and mathematics education, 6% of students were taught by teachers with a major in mathematical education but not mathematics, 45% of students were taught by teachers with a major in mathematics but not mathematics education, and 17% of students were taught by teachers with a major in all other disciplines" (Mullis et al., 2012. p. 282). A critical examination of the TIMSS international results reveals that the responses of the teachers were almost exclusively centred on one category, which was primarily concerned with mathematics and mathematics education. This circumstance could turn the estimation of the slope and the significant effect somewhat redundant or ineffective. However, the findings of the present study are congruent with those of earlier research (Mohammedpour, 2012; Chepete, 2008). For instance, Mohammedpour's study revealed that teachers who specialised in mathematics and mathematics education had little impact on the math performance of Singaporean students.

The Formal Education of Mathematics Teachers was analysed to determine its contribution to mathematics performance of grade eight students in both nations. The results reveal that the qualifications of eighth-grade mathematics teachers correlate positively with the mathematical achievement of students in Ghana and Singapore. In terms of statistical significance and variance explained, the variable had a differential effect on mathematics achievement. For instance, the result indicated that the component was positively and significantly associated with math achievement in Ghana. The findings support previous studies which investigated the effects of teachers' formal education and mathematics achievement (Casian, et al., 2021; Antony & Elangkumaran, 2020; Nyatsikor, 2019; Klassen & Dolan, 2015; Hanushek

& Rivkin, 2006; Anamuah-Mensah et al., 2004; 2008). Anamuah-Mensah et al. (2004; 2008) analysed TIMSS results and found a strong connection between the academic qualification of teachers in Ghana and students' achievement in mathematics. The results indicated that those students taught by teachers who possessed at least a bachelor's degree had a statistically significant higher mean score than those taught by teachers who did not. Highly educated teachers may have a deeper understanding of the subject to be taught. As Shulman (1987) observed, "teaching begins with a teacher's understanding of what is to be learned and how it is to be taught" (p.7). These findings validate the policies behind the current teacher education reforms in Ghana. The current reforms specifically upgrade all the training colleges, now called colleges of education in Ghana, into degree-awarding institutions. This was to ensure that the teachers' formal education for a basic school teacher in Ghana was at least a first degree. This was implemented to enhance students' academic achievement. Also, aligning the finding to the conceptual model underpinning the study, teacher qualifications form part of the personal characteristics an individual teacher brings into the classroom environment, and these features influence the success levels of the individual students. Teachers who had degree qualifications were more competent in the specialist subject areas, which enabled them to create interesting psychological environments to augment teaching and learning. Highly educated teachers were more likely to develop high levels of confidence and motivation to positively influence the kinds of environments (schools and classrooms) they operated in (Nyatsikor, 2019). The study has given school administrators with a solid platform and support for implementing practises in teacher induction and teacher recruiting programmes. A teacher with a skill that has been proved to improve students' academic performance would have a significant hiring advantage.

In contrast, the factor was positively but insignificantly associated with mathematics achievement in the Singaporean educational context. This finding is surprising because it was anticipated that the factor would significantly contribute to the Singaporean student's excellent performance in the TIMSS mathematics assessment. The lack of variability in response to certain teacher factors, resulting in an underestimating of their link with achievement, could be a possible reason for this disturbing finding. For example, 10% of Singaporean eighth graders were taught by teachers with a postgraduate university degree (master's doctorate or other postgraduate degree or diploma); 87% of students were taught by teachers with a bachelor's degree or equivalent but not a postgraduate degree; and 2% of students were taught by teachers with post-secondary education but not a bachelor's degree (Mullis et al., 2012). Most teacher responses to this variable in the Singaporean context fell into a single group, which may render this variable's effect superfluous. In other words, the variable lacked variability, which led to a large underestimation of its effect on mathematical achievement.

Importantly, the insignificant influence of this variable on mathematics proficiency in the Singaporean setting does not suggest that it is not an issue of resource for teaching. However, the finding resonates with previous studies which considered the effects of the educational qualification of teachers and mathematics achievement. A multilevel comparison research, for instance, revealed that educational degree had no significant effect on mathematical achievement (Lamp & Fullarton, 2002). Similarly, the academic credentials of teachers in Singapore had little effect on students' mathematical achievement (Mohammedpour, 2012). Chepete (2008) similarly found that teachers' formal education had no significant effect on eighth graders' mathematical performance. Future researchers may wish consider investigating why teacher qualifications have no effect on the math performance of students in nations that perform well on the TIMSS test as a result of these findings.

It was anticipated that the Engaged Students Learning Through Instruction factor would have a considerable impact on students' mathematics achievement. Unfortunately, the results indicated that the variable had no significant impact on the mathematical achievement of students in both countries. Also, this variable's contribution to the total difference in the mathematical performance of Singaporean and Ghanaian students was minimal. Despite the findings of this study, instruction to engage students' learning, which “refers to the cognitive interaction between students and instructional content and may take the form of listening to the teacher or providing additional explanations to problem solutions” (Mullis et al., 2012, p. 375), might influence students' mathematics achievement. Students' average mathematics scores were slightly higher if teachers employed engaging instruction in many lessons, as opposed to nearly half of the lessons, according to Mullis et al. (2012).

It was discovered that teacher effectiveness, as demonstrated by teachers' teaching to engage students' learning, is the most significant factor influencing student mathematical achievement (Sanders, et al., 1997). Butakor

(2016) discovered that students who were more involved in the instructional practises did better than those who were not.

According to the study's findings, the Teacher's Condition of Service factor was positively but insignificantly connected with the mathematical achievement of students in both countries. The findings are congruent with those of other investigations (e.g., Mullis et al., 2012). Mullis et al. (2012) demonstrated that, across the two countries, students whose teachers had minimal concerns with the condition of service did much better than those whose teachers had intermediate problems. This variable has proved that regardless of the qualities and variations that may exist between two or more countries, the greater the teachers' satisfaction with their working conditions, the higher their students' math achievement. The contribution of this variable to the variation in student mathematics achievement was only 1% in favour of Singaporean students. Similarly, the factor had a greater impact on the math achievement of Singaporean students than that of their peers. The insignificant impact of this factor on the mathematical achievement of children could be attributed to the absence of variation in the working conditions of instructors in both countries. Many children in Singapore are instructed by teachers with improved working circumstances. In contrast, many students in Ghana are taught by teachers who are unhappy with their working conditions.

The findings of this current study notwithstanding, studies have shown that teachers' condition of service, which is a major determinant of teachers' career satisfaction, significantly contributes to the mathematics achievement of students in different countries (Toropova, Myrberg & Johansson, 2021;

Kaniuka & Kaniuka, 2019; Dobbie & Fryer, 2013; Johnson et al., 2012). Hence, policymakers, administrators, and education players must seriously take into consideration strategies to improve teachers' conditions of service for higher performance in student mathematics achievement and general academic endeavours.

This study discovered that teachers' confidence in teaching math has a negative and insignificant effect on student achievement in math in both nations. This result is consistent with prior research findings. For instance, Demirtasli, Dibek, and Yavuz (2017) discovered that instructors' confidence in the classroom had no effect on student mathematical achievement. Nonetheless, the study literature reveals that teachers' confidence in teaching mathematics has a favourable impact on students' mathematical achievement (Liang & Jea, 2015; Ker, 2017). In other words, the results of these investigations indicate that teachers' confidence in the classroom increases the mathematical achievement of their students. It was anticipated that the confidence of Singaporean instructors whose students consistently perform well in mathematics would reflect their own confidence in teaching mathematics. A social-cultural perspective can provide one plausible answer. According to Ker (2016), Singaporeans tend to have modest perceptions of their skills, despite having high performance expectations. Typically, they do not boast about their abilities, even when they possess them. According to Ker, (2016), most East Asian countries, such as Korea, Japan, and Hong Kong SAR, where the degree of "extremely confident" is quite low on the list of all TIMSS participating countries, have teachers with low CTM.

According to Ker (2016), confidence may represent modesty, which is regarded as a virtue in the cultures of most East Asian nations. It is hoped that the issues addressed here will lead to additional research on how culture influences the performance of individuals on large-scale mathematics assessments.

The variable Instruction as Affected by the Mathematics Resource Shortage factor was included in the analysis to determine its effect on the math achievement of grade eight students in both nations. Based on the literature, it is anticipated that the variable will contributes to math achievement of students (Mullis et al., 2012; Martin et al., 2016; Mullis et al., 2016a). According to Mullis et al. (2012), the average mathematics success gap between students attending schools where teaching was not significantly impacted by resource shortages and those who attended schools where instruction was significantly impacted by resource shortages was 35 points. However, the findings of the present study suggested that the variable had no significantly impact on math performance of students in both nations. The lack of variety in responses to this variable is a possible reason for these disturbing findings. For instance, 10 % of Ghanaian eighth-graders attended schools where instruction was not affected by the resource scarcity; 88 % attended schools where instruction was slightly affected; and 7 % attended schools where instruction was severely affected (Mullis et al., 2012). Principals' responses in relation to this variable in the Ghanaian context were concentrated in almost one category, and this has the possibility of making the effect of this variable insignificant. Similar responses were observed in the Singaporean data. About 67% and 22% of students in Singapore attended classes where instruction was not affected and somewhat affected, respectively. Surprisingly, this finding resonates with previous studies which have considered school resources and their effects on mathematics achievement (OECD, 2010; Afana, & Lietz, 2010; Woessmann, 2003). For instance, the 2009 (PISA) suggests that school resources are not significantly associated to achievement of student across countries (OECD, 2010). Also, Woessmann (2003) discovered that inequalities in school resources have little impact on the performance of students in different nations.

The insignificant influence of this variable on mathematics achievement found in this and previous studies does not indicate that mathematics resources do not contribute to mathematics achievement. Several research studies have demonstrated that mathematics resources have a substantial effect on mathematics achievement (VaraidzaiMakondo & Makondo, 2020; Sullivan, Parry, McConney, 2013; Kalejaiye, 2005; Ale, 2000). In their study, VaraidzaiMakondo and Makondo (2020) discovered that proper mathematical resources improve students' maths performance. In a similar vein, Ale (2000) reported that a lack of acceptable materials for use by mathematics teachers exacerbates the issue of poor academic achievement in the subject. This suggests that students may perform less well in math if their schools lack adequate math resources.

The results of the current study revealed that Ghanaian teachers' career satisfaction had a negative and insignificant effect on eighth-grade students' mathematics achievement. This means that students in Ghana with satisfied teachers obtained lower average mathematics scores. These findings resonate with some previous studies. For example, Lee, Tam, and Javalgi (2010) discovered that there was no significant effect of teacher job satisfaction on the academic performance of students. Also, Iqbal, Fakhra, Farooqi, and Shabbir (2016) found no significant relationship between job satisfaction of teachers and students' performance. Similar findings were observed for teachers in England, where a correlation between a higher degree of professional satisfaction and increased student accomplishment was not identified. In addition, the variable contributed a little bit to the total variance in the mathematical performance of Ghanaian students.

On the contrary, the factor significantly and positively contributed to Singaporean students' mathematics achievement. These findings for the Singaporean students are consistent with several studies (Liang & Jea, 2015; Yildirim & Demir-Bilican, 2014; Su & He, 2020; Asif, Fakhra, Tahir, & Shabbir, 2016). These investigations demonstrated a correlation between career satisfaction and mathematical achievement. Specifically, Su and He (2020) discovered that instructors' job satisfaction significantly predicted students' mathematical achievement. Similarly, Asif et al. (2016) found a significant relationship between instructors' job satisfaction and students' academic accomplishment; that is, teachers with a higher level of satisfaction facilitate an increase in students' academic achievement. Moreover, the factor was the second most influential in determining Singaporean students' mathematics achievement. This factor contributed the most to the variance in the mathematical performance of Singaporean students. Almost 26 % of the variance in how well Singaporean students performed in math at school was attributable to the job satisfaction of their teachers. This accounted for 78% of the overall difference.

The findings of this current study in terms of job satisfaction of teachers and mathematics achievement show inconsistent conclusions. One possible reason for these mixed findings, according to Gu and Zhou (2020), is the fact that the effect of this variable might be influenced by several factors. For example, a meta-analysis by Iaffaldano and Muchinsky (1985) revealed that there was a significant positive link between teacher satisfaction and students' performance, with size and type of region moderating the effect.

The findings of the effect on Singaporean teacher satisfaction on math performance suggest that teachers' career satisfaction contributes significantly to the mathematics achievement of Singaporean students. This has practical implications for educational policymakers and school administrators in Singapore and elsewhere. Singapore must continue to sustain and improve on the existing teachers' career satisfaction strategies in order to maintain and improve the mathematics achievement of students. Ghanaian education policymakers might want to take a cue from the Singaporean findings to improve the job satisfaction of teachers. This could have a significant impact on Ghanaian students' mathematics achievement.

The results from the study showed that School Size was positively and significantly linked to students' mathematics achievement in both countries. However, the results indicate that there was a differential contribution of this variable to school level variance in students' achievement. For example, the factor contributed 9.0% to the Ghanaian level two variance, whereas it contributed 25% to the Singaporean school level variance. The positive effect of school size on mathematics achievement means that the larger the school, the higher the mathematics achievement of students in both countries. In fact, it was expected that small school size would increase mathematics achievement and vice versa. This finding conflicts with the general belief that the smaller the school size, the higher the mathematics achievement (Slate & Jones, 2005; Wyse, Keesler & Schneider, 2008; Lee, 2000; Wasley et al., 2000). For example, Slate and Jones (2005) indicated in their study that most of the evidence indicates that students' academic achievement is better in small schools.

Despite this prevalent notion, actual evidence regarding the relationship between school size and mathematics achievement is highly ambiguous. As stated previously, a few studies have found that small schools are associated with better levels of accomplishment. Others, however, have found that there is no link between these two variables. (Jones & Ezeife, 2011; Gershenson & Langbein, 2015). There is a state of confusion in the literature in terms of which optimal school size can produce the desired mathematics and general academic achievement of students. Several researches have speculated on potential explanations for the discrepancy of published results. For instance, Wyse et al. (2008) stated that students in small schools may have higher success scores not because of the size of the school they attend, but because students in these sorts of schools are fundamentally distinct from those in larger schools. There may be factors unrelated to school size that influence the achievement of students in smaller schools. According to Kuziemko (2006), at least a portion of the "present misunderstanding in the literature" can be attributed to the fact that numerous earlier studies of school size were cross-sectional and correlational. Some studies have revealed that students in large school sizes do better than their counterparts in small school sizes in mathematics.

The current finding of this study notwithstanding, studies on school size have suggested that other variables may interact with the size of the school to contribute to the mathematics achievement of students. Slate and Jones (2005), for instance, claimed that the economic and curricular advantages of large schools are frequently exaggerated and that a range of factors influence or mediate the relationship between school size and student academic attainment.

In this current study, class size has demonstrated that it is a significant contributor to mathematics achievement in both low- and high-performing countries in TIMSS. These results resonate with findings from previous studies (Cotton, 1996; Leithwood & Jantzi, 2009; Andrews, Duncombe & Yinger, 2002).

The results of this study reveal that the Class Size variable contributed considerably but only marginally to the mathematical achievement of students in both nations. There was, however, a differential influence on the average math achievement of students. For example, the relationship between this variable and the average mathematical achievement of Ghanaian students was negative, whereas it was positive for Singaporean students. The contribution of this variable to the level two variance in Singapore was significantly higher than its peers. This study demonstrates that this factor is a major predictor of student math achievement, regardless of the country's features. This indicates that the size of the classroom influences the math performance of students. The influence of class size on students' math achievement in literature is inconsistent, as demonstrated by these results. While some studies indicate that increasing class size has a negative impact on student achievement (Westerlund, 2008; Bandiera et al., 2010; Kokkelenberg et al., 2006; Kogl et al., 2016) others demonstrate positive effects (Nyatsikor, 2019; Butakor, 2015; Pong & Pallas, 2001; Owuor, 2018), as well as mixed or no effects (Hancock, 1996; De Paola et al., 2013; Edgell, 1981; Gleason, 2012; Olson et al., 2011; Hill, 1998; Matta et al., 2015). However, empirical research consistently supports the notion that when class size is reduced, both students and teachers perceive a better learning environment. For example, students in smaller classes report increased learning (Monks & Schmidt, 2011; Benton & Pallett, 2013), greater engagement (Gleason, 2012), and a more positive attitude toward the subject. (Edgell, 1981; Benton & Pallett, 2013). This academic advantage of class reduction notwithstanding, there is also an economic dimension to class size reduction. This means that a reduction in class size has implications for government spending and budget on education. It implies more classrooms, more teachers, and additional school resources. According to research on schools and class sizes, the economic and academic benefits of class reduction are sometimes overestimated, and several variables affect the correlation between students' academic achievement and class size (Slate & Jones, 2005). Therefore, educational decision-makers must establish reform strategies based on a balanced examination of all relevant criteria pertaining to class size. This is because some variables might mediate the influence of class size on mathematics achievement (Slate & Jones, 2005). For example, Pong and Pallas (2001) argued in their studies that curriculum coverage and instructional practices play mediating roles in the association between mathematics achievement and class size of grade eight students.

Summary of Key Findings

The study indicated that the attainment or performance in mathematics of Ghanaian and Singaporean eighth-graders is mostly determined by individual or student-level characteristics. The total variance in mathematics performance attributable to the classroom/school level is less than that attributable to the individual student. In addition, the results of this study provide more evidence that there is a correlation between student, classroom, and school-level characteristics and math achievement, as predicted by the conceptual model employed in this investigation.

At student level, the study found the following:

1. The attitude (SVM, SLM, SCM) of Singaporean eighth grade students towards mathematics was more effective in explaining student mathematics achievement than their counterpart.
2. Singaporean eight grade students were more confident in doing mathematics than their counterpart.
3. The eighth-grade mathematics achievement of Singaporean students was significantly most influenced by students' confidence in their math ability.
4. Ghanaian eighth grade students liked learning mathematics more than their counterpart.
5. Students' enjoyment of learning mathematics was the most influential and biggest contributor to their eighth-grade mathematics

achievement. The same variable was the second most impactful variable on the mathematics achievement of Singaporean students.

6. A student engaged in mathematics lessons was significantly and positively contributed to math performance of students in both countries. But Singaporean eighth students were more engaged in terms of mathematics lesson than their counterpart

At the classroom/school level factor, the study found the following:

1. The School Discipline and Safety factor had the greatest impact on the mathematical achievement of students from both nations.
2. The Safe and Orderly School factor contributes positively and significantly to the mathematical achievement of eighth grade students in both nations and is the second most influential factor in Ghanaian students' mathematics achievement.
3. Despite countries characteristics, teaching experience factor positively and significantly contributes to mathematics an achievement in both countries.
4. School Emphasis on Academic Achievement factor suggests to be most important factor that might influence Singaporean student mathematics achievement at the school-level. Similarly, for Ghana, it seems to be third most important factor that might affect Ghanaian students' mathematics achievement.
5. Frequency of test positively and significantly contributes to mathematics achievement in both countries but was more influential on math performance of Singaporean students.

6. Teacher major in education and mathematics was insignificantly linked to math performance of Singaporean students.
7. Mathematics teachers' formal education positively and significantly contributes to math performance of Ghanaian students.
8. Instruction to engage student learning seems not to have significant effect on students' math performance in both countries.
9. Despite the high-performance of Singaporean student, teachers' confidence in teaching mathematics seems not have significant contribution to student mathematics achievement.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Overview of the Study

The important discoveries are summarised in this concluding chapter, along with some recommendations for the MOE, the GES, and policymakers. There were also suggestions for additional investigation. The main aim of this investigation was to compare eighth-grade mathematical achievement in Ghanaian and Singaporean students using TIMSS 2011 and to learn from the Singaporean education system, which consistently supports high math achievement. The study looked at which of the two levels (student or classroom/school) had the most impact on mathematics learning in the two countries.

The researcher also looked at which of the TIMSS 2011 student-level factors and classroom/school-level contextual factors were the best or strongest predictors of eighth-grade math achievement in the two nations.

This study was based on empirical evidence established by TIMSS reports that indicated Ghanaian eight-grade students' consistent abysmal performance in mathematics across the years of participation (i.e., 2003, 2007, and 2011). On the contrary, TIMSS reports indicated consistent top-level performance of Singaporean eighth grade students in math across the years of participation (i.e., 1999, 2003, 2007, 2011, 2015, and 2019). The desire to learn from the Singaporean education system that facilitates high-consistent mathematics achievement motivated this current study. The study was directed by three research questions to provide light on the problem described in the preceding parts.

1. Which of the two levels (student and classroom/school) has the most impact on the math achievement of eighth grade students from Ghana and Singapore?
2. What is the contribution of selected student-level factors to the mathematics achievement of eighth grade Ghanaian and Singaporean students?
3. What is the contribution of selected classroom/school-level factors to the mathematics achievement of eighth grade Ghanaian and Singaporean students?

A comparative research strategy was used in this study, which is a quantitative alternative. Comparative study is a type of research that aims to make comparisons between countries. The drive of this research was to compare the mathematical achievement of eighth-grade students in Ghana and Singapore using TIMSS 2011. Due to the study's objective, the study's design was found appropriate. The final sample for Ghanaian eighth grade students in TIMSS 2011 consisted of 7,323 students nested within 161 teachers, which meant nested within 161 schools, after employing the expectation maximisation (EM) technique to replace missing data at two levels (i.e., student and classroom/school) for both countries. In TIMSS 2011, the final sample for Singapore eighth-grade students consisted of 5,251 students spread across 129 classrooms. A two-level HLM was employed to investigate the contribution or effect of level one and level two factors on eighth grade students' mathematical achievement. The classroom/school represented the second level. Because the TIMSS data used in the analysis was nested, this statistical approach was applied.

Key Findings

The results of the study indicate that:

1. The mathematics achievement of eighth-grade Ghanaian and Singaporean students is largely impacted by student-level factors or characteristics.
2. There is an association between students, classroom and school characteristics and math performance, as shown by the conceptual model adopted for the current research.

   The students' level results indicate that:
3. Singaporean eighth-graders' attitudes toward math (SVM, SLM, and SCM) were more effective than those of their counterparts in explaining their math achievement.
4. Singaporean eighth grade students were more confident in doing mathematics than their counterparts.
5. Singaporean eighth graders' confidence in math was the most important factor in their math success.
6. Ghanaian eighth grade students like learning mathematics more than their counterparts do.
7. A student like learning mathematics was the most influential and strongest contributor to the achievement of student in Ghana. The same variable was the second most influential on Singaporean students' math performance.
8. The frequency of mathematics homework contributed positively and significantly to the mathematics performance of Singaporean students

but significantly and negatively to math performance of Ghanaian students.

9. Students engaged in mathematics lessons significantly and positively contributed to the mathematics achievement of students in both countries. However, Singaporean eighth graders were more engaged in mathematics lessons than their counterparts.

At the classroom/school level factors, the study indicates that:

10. The most influential factor on eighth-grade mathematics achievement in Ghana was school discipline and safety.
11. The second most important variable on the math performance of Ghanaian students was safe and orderly school and significantly contributes to the math achievement of eighth grade students in both countries.
12. In both countries, the teaching experience factor has a positive and significant influence on mathematics performance, no matter what their country's differences are.
13. School emphasis on the academic achievement factor is suggested to be the most important factor that might influence Singaporean student mathematics achievement. Similarly, for Ghana, it seems to be the third most important factor that could affect how well Ghanaian students do in math.
14. The more often students took tests, the higher they scored in mathematics. In both countries, that was the case, but the effect was more effective for the Singaporean students than their counterparts.

15. The mathematics achievement of Singaporean students was unrelated to the teacher's major in education and mathematics.
16. Ghanaian mathematics teachers’ formal education significantly and positively contributes to the math performance of Ghanaian students.
17. There was no significant influence of instruction to engage student learning on students’ math achievement in both countries.
18. There was no significant contribution of teachers’ confidence in teaching mathematics to mathematics achievement of student despite the high performance of Singaporean students.

Conclusions

Based on the results and discussions, the following main conclusions are drawn: Individual or student-level factors drive grade eight mathematics achievement in Ghanaian and Singaporean students. Based on the conceptual model used in this current study, there is a connection between school classroom, student-level, characteristics, and students' mathematical performance. Regardless of country characteristics, student level variables such as student confidence in doing mathematics, students' like for learning math, the frequency of math homework, and students engaged in math lessons all contribute significantly to eighth-grade mathematics achievement. Similarly, regardless of nation characteristics, school-level factors such as school emphasis on academic, safe and orderly schools, teaching experience, and school discipline and safety contribute considerably to eighth-grade students' mathematical achievement. Thus, the findings of this and prior studies shed light on various factors or variables that explain and influence how well people around the world perform in math.

The most impactful factors on Ghanaian eighth graders' math performance at the student and school levels, respectively, were school students' enjoyment of learning mathematics, as well as discipline and safety. Similarly, at the student and school levels, students' confidence in doing mathematics and school emphasis on academic success were the most powerful contributors to Singaporean eighth graders' mathematics achievement.

The current investigation produced some surprising results. Student value mathematics, instruction to engage student learning, and teachers' confidence in teaching mathematics, for example, had no significant effects on Singaporean students' mathematical achievement. Despite achieving well in various worldwide large-scale exams (e.g., TIMSS and PISA), it has been hypothesised that East-Asian students, especially Singaporeans, have less value for mathematics. From a social-cultural standpoint, one plausible explanation for teachers' confidence in teaching mathematics can be found. Singaporeans have a reputation for being conservative in their estimations of their own skills, but they hold themselves to high performance standards. Even when they do have such abilities, they rarely boast about them. In terms of instruction to engage students in learning, the current research hypothesised that most Singaporean students had teachers who delivered such instruction. Thus, the variable lacked sufficient variation to have a substantial impact on mathematics proficiency.

Overall, the study found that student characteristics variables in both countries largely improve mathematics learning among eighth-grade students. The study found that students' enjoyment of mathematics, school safety and discipline were the most influential determinants on grade eight students math performance in Ghana. On the other hand, school emphasis on academic success and students' confidence in doing mathematics were the dominant contributors to mathematics among Singaporean students. Furthermore, the study has revealed some significant implementable factors that are suggested to have influenced the achievement of Singaporean grade eight students in TIMSS 2011. It is suggested that Ghana take a critical look at these variables in effort to enhance the math achievement of eighth grade students and improve performance in subsequent international large-scale assessments (e.g., TIMSS 2023).

Recommendations for Practice and Policy

The following suggestions have been provided based on the study's key findings: The results indicate that in both nations, eighth-grade math achievement was substantially determined by individual student characteristics. Therefore, it has been suggested that both the MOE and the GES examine seriously the traits of students that can be cultivated at both the classroom and school levels. Special consideration should be given to student characteristics that have a major impact on math achievement.

1. At the student level, the data results suggest that student enjoy learning mathematics; was the most influential and strongest contributor to mathematics achievement for eighth-grade students in Ghana and the second most influential variable on mathematics achievement for students in Singapore. This demonstrates the influence of this variable on mathematics achievement. Therefore, it is recommended that various education stakeholders (e.g., educators and parents) foster

situations at home and school that maximise students' capacity to enjoy learning mathematics. The findings of the study suggest that at the classroom/school level, school discipline and safety, as well as a safe and orderly school, were the first and second most influential factors on the mathematics achievement of Ghanaian eighth grade students, respectively. Thus, it is recommended that the educators and parents in collaboration with GES strive to find effective and pragmatic ways of making the school climate a safe and conducive environment for learning. It is suggested that if Ghana anticipates greater achievement in mathematics among eighth-grade students, then the school climate must be tackled with all sense of responsibility.

2. There should also be more experienced teachers in the eighth-grade class, since this current study shows that teacher experience is linked to math achievement in both countries.
3. Furthermore, effort should be made to ensure that math homework and tests are given to students often and that the homework and tests are marked so that students get the correct feedback. This is because the results of the study revealed that homework significantly and positively predicts math performance of students of Singapore as high achieving nation in TIMSS mathematics.
4. The findings from this study can be extrapolated to other nations. The findings could be utilised by education policymakers in other nations to improve their education systems. Specifically, some characteristics (such as student confidence in math, a safe and orderly school, school discipline and safety, student motivation in learning mathematics and

teacher experience) have the potential to be universal factors. This is because prior research and the present study indicated that these variables had a significant impact on math achievement regardless of the country's peculiarities.

Contribution of the study to knowledge

The study's findings serve as a good foundation for policy decisions in the effort to raise the mathematics achievement of eighth-grade students in both the Ghanaian and Singaporean educational systems. The results of this study, for instance, will help stakeholders in the education system identify the most crucial and important factors that influence students' mathematics achievement, such as how much they enjoy learning mathematics, the safety and discipline of the school, and whether or not the school is safe and orderly.

Secondly, the findings show that in both countries, student factors significantly influenced eighth-grade math achievement. These results support the notion that student-centred teaching greatly raises students' academic achievement. In order to increase student's achievement in mathematics, it has been recommended that parents, teachers, GES, and other stakeholders carefully consider the characteristics of students that can be fostered at the home, classroom, and school levels.

Thirdly, the successful application of aspects of BST to the study implied that the theoretical models are applicable in explaining learning outcomes in the Ghanaian and Singaporean educational contexts. Aligning with the BST, the study results indicated that students' learning outcomes were influenced by the characteristics of persons (e.g. student's value for mathematics, teachers' professional status and teaching experience) and microsystem (School Size, School Discipline and Safety). Consequently, the theory offer effective theoretical model to adapt to tackle Ghana's and Singapore educational challenges at student, classroom and schools levels even though the limited number of variables in the dataset limited the full application of the theory.

Finally, this research adds to the body of knowledge on comparative schooling, achievement, and school effectiveness. In the quest for answers to the numerous problems affecting grade eight education in Ghana, Singapore, and other places, the findings, conclusions, and implications derived from this study may serve as the foundation for more studies to be replicated. The study makes a significant addition to the current debate on international education policy and practice.

Suggestions for Future Research

During the research, a few issues that are relevant to the topic of the study but require their own investigation and work arose.

1. The results from this current study emanated from the perspective of the school; nonetheless, they are unable to explain the actual learning disparities between students accounted for by diverse cultural backgrounds. Future study is proposed to concentrate on the learning processes and experiences of students from diverse cultural backgrounds. This could demonstrate how to bridge the gap between countries with low TIMSS scores and those with high TIMSS scores.
2. According to the findings of the study, student confidence or self-confidence in mathematics was the most significant contributor to math performance. In math education, however, increasing students'

confidence in mathematics is a global concern. Therefore, further research is needed to reveal how to improve math confidence of students.

3. Other factors influence students' mathematics achievement than those currently being investigated in this study. There were so many TIMSS variables that they could not be considered in one study. In future studies, it is possible to look at factors that were not considered in this current study.
4. The unconditional models investigated implied that the total number of variables could not explain a greater proportion of the achievement variances. Exploring these extra factors in the future will help provide further and comprehensive insight into the factors that affect mathematics achievement in both countries.
5. Additionally, to the numerical data that formed the basis of the current study, the government of Ghana, in collaboration with other development partners, may wish to also collect qualitative data from students, teachers, and school administrators. This exercise will help the adoption of a more pragmatic mixed methods approach in future studies to investigate similar issues from diverse perspectives. Qualitative data that is obtained from observations and in-depth interviews could help us better understand why people choose certain paths or why certain schools work the way they do. (Hammersley, 2012).
6. Findings from current studies suggest that teachers' major in education, students' value of mathematics and instruction to engage students'

learning, are insignificantly related to the math performance of Singaporean students. Thus, it is suggested that these factors be re-examined in future research.

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APPENDICES

Appendix A

Table 1A: Students-Level Variables and their Properties

Variable	Definition	Type	Coding	Original Name	Original Coding
BSMMAT01-05	Plausible values - Overall math	Continuous	There are 5 plausible values in TIMSS	BSMMAT01-BSMMAT05	N/A
Sex	Sex of students	Nominal	0 'Male' 1 'Female'	ITSEX	2 'Male' 1 'Female'
Home Educational	Home educational resources (index)*	Nominal	0 'Few Resources' 1 'Some Resources' 2'Many Resource'	**BSDGHER**	1'Many Resource' 2 'Some Resources' 3 'Few Resources'
Students Value Mathematics	*Students value learning mathematics (index)*	Nominal	0 'Do Not Value' 1 'Somewhat Value' 2 'Somewhat Value'	BSDGSVM	1'Value' 2 'Somewhat Value' 3 'Do Not Value'
Students Like doing Mathematics	Students like learning mathematics (index)*	Ordinal	0 'Do not like learning math' 1 'Like learning math' 2 'Very much like learning math'	BSDGSLM	3 'Do not like…' 2 'Like…' 1 'Very much like…'
Students Confidence with Mathematics	Student confident in mathematics (index)*	Ordinal	0 'Not confident in math' 1 'Confident in math' 2 'Very confident in math'	BSDGSCM	3 'Not confident…' 2 'Confident…' 1 'Very confident…'

Students' Educational Expectation	How far in education students expect to go (index)*	Ordinal	0 "Finish Lower or Upper Secondary 1 'Finish Post-Secondary, Non-Tertiary or Short Cycle Tertiary' 2 'Finish Bachelor's or equivalent' 3 'Finish Postgraduate degree'	BSBG08	1 'Finish Lower…' 2 'Finish Upper…' 3 'Finish Post-…' 4 'Finish Short-…' 5 'Finish Bachelor's…' 'Finish Postgrad…'
Frequency of Mathematics Homework	How often teacher give student homework	Ordinal	0" Never" 1" less than once a Week" 2" More than once a Week" 3" Every Day"	BSBM20A	1" Every Day" 2" 3or 4 Times a Week" 3" 1or 2 Times a Week" 4" less than once a Week" 5" Never"
Students Bullied at School	*Students Bullied at School (index)*	Ordinal	0 'About Weekly' 1'About Monthly' 2 'Almost Never'	BSDGSBS	1'Almost Never' 2 'About Monthly' 3 'About Weekly'
Instruction to Engage Student in Learning	Student perception of engaging teaching in math lessons (index)*	Ordinal	0 'Less than engaging' 1 'Engaging' 2'Very engaging'	BSDGEML	3 'Less than engaging' 2 'Engaging' 1 'Very engaging'

Table 2A: Classroom/School -Level Variables and their Properties

Variable	Definition	Type	Coding	Original Name	Original Coding
School Discipline and Safety	*School Discipline and Safety (index)*	Ordinal	0 'Moderate Problem' 1 'Minor Problem' 2 'Hardly any Problem'	BCDGDAS	3 'Moderate Problem' 2 'Minor Problem' 1 'Hardly any Problem'
Safe and Orderly Schools (SOS)	*Safe And Orderly School (index)*	Ordinal	0 'Not Safe and Orderly' 1 'Somewhat Safe and Orderly' 2 'Safe and Orderly'	BTDGSOS	3'Not Safe and Orderly' 2 'Somewhat Safe and Orderly' 1 'Safe and Orderly'
Teachers' Experience (TE)	*Teachers Years of Experience*	Ordinal	0 'Less than Five Years' 1 'At Least 5 But Less Ten Years' 2 'At Least 10 But Less Than 20 Years' 3 '20 Years or More'	BTDG01	1'20 Years or More' 2 'At Least 10 But Less Than 20 Years' 3 'At Least 5 But Less Than 10 Years' 4 'Less Than 5 Years'
School Emphasis on Academic Success (SEAS)	School emphasis on academic success (index)*	Ordinal	0'Medium emphasis' 1'High emphasis' 2 'Very high emphasis'	BCDGEAS	3 'Medium emphasis' 2 'High emphasis' 1 'Very high emphasis'
Frequency of Test (FT)	How often math tests are given to students	Ordinal	0 'Never' 1 'A few times a year' 2 'About once a month' 3 'About every two weeks' 4 'About once a week'	BTBM27	5 'Never' 4 'A few times a year' 3'About once a month' 2 'About every two weeks' 1 'About once a week'

Teachers Majoring in Education and Mathematics*	*Teachers majored in education and math*	Ordinal	0 ‘Major in math education and math’ 1 ‘other subjects’	BTDM05	1 ‘Major in math education and major in math’ 2 ‘Major in math education but no major in math’ 3 ‘Major in math education but no major in math education’ 4 ‘All other majors 6 ‘No formal education beyond upper secondary'
Mathematics Teachers’ Formal Education	Level of formal education completed	Ordinal	0 **‘Not completed** <ISCED>’ 1 ‘<ISCED level 3>’ 2 ‘<ISCED level 4>’ 3 ‘<ISCED level 5B>’ **4** ‘<ISCED level 5A 1ST>’ **5** ‘<ISCED level 5B 2ED>’	BTBG04	1 **‘Not completed** <ISCED>’ 2 ‘<ISCED level 3>’ 3 ‘<ISCED level 4>’ 4 ‘<ISCED level 5B>’ **5** ‘<ISCED level 5A 1ST>’ **6** ‘<ISCED level 5B 2ED>’
Instruction to Engage Students Learning (IESL)	*Instruction To Engage Students (index)*	Ordinal	0 ‘Some lessons’ 1‘About half of the lessons’ 2 ‘Most lessons’	BTDGIES	1 ‘Most lessons’ 2‘About half of the lessons’ 3 ‘Some lessons’
Teacher Condition of Service (TCS)	*Teachers report problems with working conditions (index)*	Ordinal	0 ‘Moderate problems’ 1‘Minor problems’ 2 ‘Hardly any problem’	BTDGTWC	1 ‘Hardly any problem’ 2 ‘Minor problems’ 3 ‘Moderate problems’
Confidence in Teaching Mathematics (CTM)	*Confidence in teaching mathematics (index)*	Ordinal	0 ‘Somewhat Confident’ 1 ‘Very Confident’	BTDMCTM	1 ‘Very Confident’ 2 ‘Somewhat Confident’

Instruction Affected by Mathematics Resource Shortage	*Instruction Affected by Mathematics Resource Shortages (index)*	Ordinal	2 'Not Affected' 1 'Somewhat Affected' 0 'Affected a lot'	BCDGMRS	1 'Not Affected' 2 'Somewhat Affected' 3 'Affected a lot'
Teachers Career Satisfaction (TCS)	*Teacher Career Satisfaction (index)*	Ordinal	0 'Less than satisfied' 1 'Somewhat satisfied' 2 'Satisfied'	BTDGTCS	1 'Satisfied' 2 'Somewhat satisfied' 3 'Less than satisfied'
School Size	Total Enrollment of Students	Scale	Range: 408 - 4369	BCBG01	N/A
Class Size	Total Enrol of Eighth Grade students	Scale	Range: 53 - 478	BCBG02	N/A

APPENDIX B

Table 1B: Students Level Predictors (Ghana)

Predictors	*β*	*SE*	*t-ratio*	*p-value*
Students Value Mathematics	22.68	2.42	9.33	0.001
Students Like doing Mathematics	24.30	1.67	14.41	0.001
Students Confidence with Mathematics	17.25	2.06	7.81	0.001
Students' Educational Expectation	10.81	1.42	7.61	0.001
Frequency of Mathematics Homework	-6.78	1.56	-4.183	0.002
Students Bullied at School	6.03	2.13	3.13	0.008
Instruction to Engage Student in Learning	3.55	2.99	1.2	0.283

Table 2B: Students Level Predictors (Singapore)

Predictors	*β*	*SE*	*t-ratio*	*p-value*
Students Value Mathematics	12.63	1.44	9.62	0.001
Students Like doing Mathematics	22.9	1.21	18.24	0.001
Students Confidence with Mathematics	28.58	1.68	17.12	0.001
Students' Educational Expectation	0.66	0.63	1.32	0.419
Frequency of Mathematics Homework	4.51	1.13	4.11	0.001
Students Bullied at School	11.41	1.25	9.10	0.001
Instruction to Engage Student in Learning	8.44	1.33	6.35	0.001

Table 3B: School Level Predictors (Ghana)

Predictors	*β*	*SE*	*t-ratio*	*p-value*
School Discipline and Safety	31.15	7.07	4.31	0.001
Safe and Orderly Schools (SOS)	28.97	6.71	4.3	0.001
Teachers' Experience (TE)	12.14	4.97	2.11	0.01
School Emphasis on Academic Success				0.02
(SEAS)	17.16	11.08	1.30	
Frequency of Test (FT)	10.56	6.21	1.56	0.05
Teachers Majoring in Education and				0.002
Mathematics	7.87	3.44	2.31	
Mathematics Teachers' Formal				0.0431
Education	3.51	7.11	1.67	
Instruction to Engaged Students				0.08
Learning (IESL)	-24.24	20.00	-1.25	
Teacher Condition of Service (TCS)	4.89	8.29	1.8	0.471
Confidence in Teaching Mathematics				0.105
(CTM)	-23.84	14.62	-1.63	
Instruction Affected by Mathematics				
Resource Shortage	-9.52	13.26	-1.17	0.411
Teachers Career Satisfaction (TCS)	-6.41	8.38	0.08	0.328
School Size	0.045	0.02	3.89	0.005
Class Size	-0.094	0.11	0.05	0.0273

Table 4 B: School Level Predictors (Singapore)

Predictors	β	SE	t-ratio	p-value
School Discipline and Safety	26.37	8.53	2.99	0.003
Safe and Orderly Schools (SOS)	23.58	8.09	2.91	0.001
Teachers' Experience (TE)	10.26	4.39	2.34	0.02
School Emphasis on Academic Success (SEAS)	32.51	6.97	4.65	0.001
Frequency of Test (FT)	25.56	8.65	2.96	0.004
Teachers Majoring in Education and Mathematics	-2.31	3.12	-0.71	0.481
Mathematics Teachers' Formal Education	3.64	4.3	0.85	0.401
Instruction to Engaged Students Learning (IESL)	6.4	6.72	0.96	0.256
Teacher Condition of Service (TCS)	8.9	6.8	1.31	0.192
Confidence in Teaching Mathematics (CTM)	-2.87	8.92	-0.322	0.748
Instruction Affected by Mathematics Resource Shortage	6.75	6.53	1.03	0.471
Teachers Career Satisfaction (TCS)	25.98	7.03	3.68	0.001
School Size	0.01	0.01	7.13	0.001
Class Size	0.35	0.08	4.56	0.001

Table 5 B: Result of Full Model (Ghana)

Variables	B	SE	T-Ratio	P-Value
Student level				
Students Value Mathematics	8.87	2.83	3.137	0.014
Students Like doing Mathematics	15.02	1.57	9.550	0.001
Students Confidence with Mathematics	16.52	1.92	8.622	0.001
Students' Educational Expectation	10.00	1.41	7.086	0.001
Frequency of Mathematics Homework	6.98	1.63	-4.288	0.001
Students Bullied at School	6.03	1.82	3.313	0.011
Instruction to Engage Student in Learning	3.50	2.94	1.19	0.279
Classroom/school level				
School Discipline and Safety	24.84	5.75	4.323	0.001
Safe and Orderly Schools (SOS)	24.44	5.74	4.257	0.001
Teachers' Experience (TE)	14.06	4.17	3.369	0.001
School Emphasis on Academic Success (SEAS)	19.43	8.96	2.169	0.032
Frequency of Test (FT)	9.39	4.36	2.152	0.033
Teachers Majoring in Education and Mathematics	6.16	2.36	2.615	0.010
Mathematics Teachers' Formal Education	1.97	3.77	0.52	0.602
Instruction to Engaged Students Learning (IESL)	-9.61	12.72	-0.76	0.451
Teacher Condition of Service (TCS)	2.06	5.33	0.39	0.70
Confidence in Teaching Mathematics (CTM)	-19.96	12.75	-1.57	0.120
Instruction Affected by Mathematics Resource Shortage	-9.30	10.07	-0.92	0.357
Teachers Career Satisfaction (TCS)	-6.51	5.30	-1.23	0.221
School Size	0.035	0.02	2.13	0.035
Class Size	-0.98	0.09	0.29	0.285

Table 6 B: Results of the Full Model (Singapore)

Variables	β	Se	T-Ratio	P-Value
Student level				
Students Value Mathematics	0.98	1.34	0.728	0.467
Students Like doing Mathematics	9.67	1.40	6.91	0.001
Students Confidence with Mathematics	28.96	1.42	20.33	0.001
Students' Educational Expectation	0.64	0.63	1.62	0.309
Frequency of Mathematics Homework	11.45	1.29	9.167	0.001
Students Bullied at School	5.17	1.13	4.58	0.001
Instruction to Engage Student in Learning	-7.85	1.39	-5.65	0.001
Classroom/school level				
School Discipline and Safety	8.81	6.72	1.31	0.192
Safe and Orderly Schools (SOS)	7.56	6.61	1.14	0.255
Teachers' Experience (TE)	6.43	3.89	1.65	0.10
School Emphasis on Academic Success (SEAS)	14.15	6.67	2.12	0.036
Frequency of Test (FT)	0.42	3.38	0.12	0.901
Teachers Majoring in Education and Mathematics	0.67	2.37	0.28	0.778
Mathematics Teachers' Formal Education	0.31	3.62	0.09	0.931
Instruction to Engaged Students Learning (IESL)	-2.94	5.46	-0.54	0.591
Teacher Condition of Service (TCS)	0.06	5.31	0.012	0.990
Confidence in Teaching Mathematics (CTM)	-16.45	7.41	-2.219	0.028
Instruction Affected by Mathematics Resource Shortage	5.33	5.02	1.062	0.290
Teachers Career Satisfaction (TCS)	14.03	6.75	2.08	0.039
School Size	0.03	0.01	3.264	0.001
Class Size	0.10	0.07	1.436	0.153

APPENDIX C- TIMSS 20011 RESULTS

Table 1 C: **Descriptive Statistics for the Level-1 and -2 Predictors for Singapore and Ghana.**

	Singapore					Ghana				
Variable Name	**N**	**Mean**	**Sd**	**Mini**	**Max**	**N**	**Mean**	**Sd**	**Mini**	**Max**
SENWGT	5927	0.08	0.2	0.01	0.13	7323	0.068	0.040	0.0070	0.28
BSMMAT01	5927	606.22	83.19	335.21	811.47	7323	335.01	85.62	39.33	655.73
BSMMAT02	5927	607.45	83.94	282.97	842.48	7323	333.68	86.19	65.89	688.21
BSMMAT03	5927	608.15	84.60	303.91	858.45	7323	331.60	86.82	57.38	710.75
BSMMAT04	5927	607.78	84.31	309.78	833.30	7323	331.56	86.74	39.00	660.22
BSMMAT05	5927	608.12	83.56	313.58	838.70	7323	333.18	86.16	50.16	729.66
Sex	5927	1.49	0.50	1.00	2.00	7323	1.4787	0.50	1.00	2.00
Home Educational	5927	0.98	0.49	0.00	2.00	7323	0.41	0.51	0.00	2.00
Students Value Mathematics	5927	1.33	0.65	0.00	2.00	7323	1.74	0.51	0.00	2.00
Students Like doing Mathematics	5927	1.09	0.74	0.00	2.00	7323	1.29	0.63	0.00	2.00
Students Confidence with Mathematics	5927	0.72	0.68	0.00	2.00	7323	0.90	0.63	0.00	2.00
Students' Educational Expectation	5927	1.29	1.28	0.00	3.00	7323	3.70	1.26	*0.00*	*5.00*
Frequency of Mathematics Homework	5927	0.95	0.65	0.00	2.00	7323	1.09	0.75	*0.00*	*2.00*
Students Bullied at School	5927	1.39	0.70	0.00	2.00	7323	.812	0.75	0.00	2.00
Instruction to Engage Student in Learning	5927	0.91	0.63	0.00	2.00	7323	1.37	0.57	0.00	2.00

Classroom/School level									
MATWGT	165	8.42	1.87	1.26	13.21	161	65.74	34.10	5.76	221.13
School Discipline and Safety	165	1.50	0.49	1.00	2.00	161	3.27	*0.57*	*2.00*	*4.00*
Safe and Orderly Schools (SOS)	165	2.58	0.53	1.00	3.00	161	3.25	0.01	2.00	4.00
Teachers' Experience (TE)	165	0.84	0.98	0.00	3.00	161	1.94	0.93	1.00	4.00
School Emphasis on Academic Success (SEAS)	165	0.64	0.57	0.00	2.00	161	3.87	0.01	2.00	4.00
Frequency of Test (FT)	165	1.5	0.49	1.00	2.00	161	2.94	0.74	1.00	4.00
Teachers Majoring in Education and Mathematics	165	1.23	1.4	0.00	4.00	161	2.73	1.44	1.00	5.00
Mathematics Teachers' Formal Education	165	4.91	1.00	0.00	6.00	161	3.52	0.98	2.00	6.00
Instruction to Engaged Students Learning (IESL)	165	1.57	0.64	0.00	2.00	161	2.91	0.28	2.00	3.00
Teacher Condition of Service (TCS)	165	1.12	0.65	0.00	2.00	161	1.48	0.63	1.00	3.00
Confidence in Teaching Mathematics (CTM)	165	1.6	.46	1.00	2.00	161	0.94	0.24	0.00	1.00
Instruction Affected by Mathematics Resource Shortage	165	1.56	0.67	0.00	2.00	161	2.09	0.34	1.00	3.00
Teachers Career Satisfaction (TCS)	165	1.19	0.57	0.00	2.00	161	2.14	0.64	1.00	3.00
School Size	165	1360.72	496.11	408.00	4369.00	161	238.12	281.77	25.00	1500.00
Class Size	165	304.27	66.21	53.00	478.00	161	65.49	49.71	7.00	295.00

APPENDIX D

NORMAL Q-Q PLOT FOR L1 RESIDUALS (GHANA)

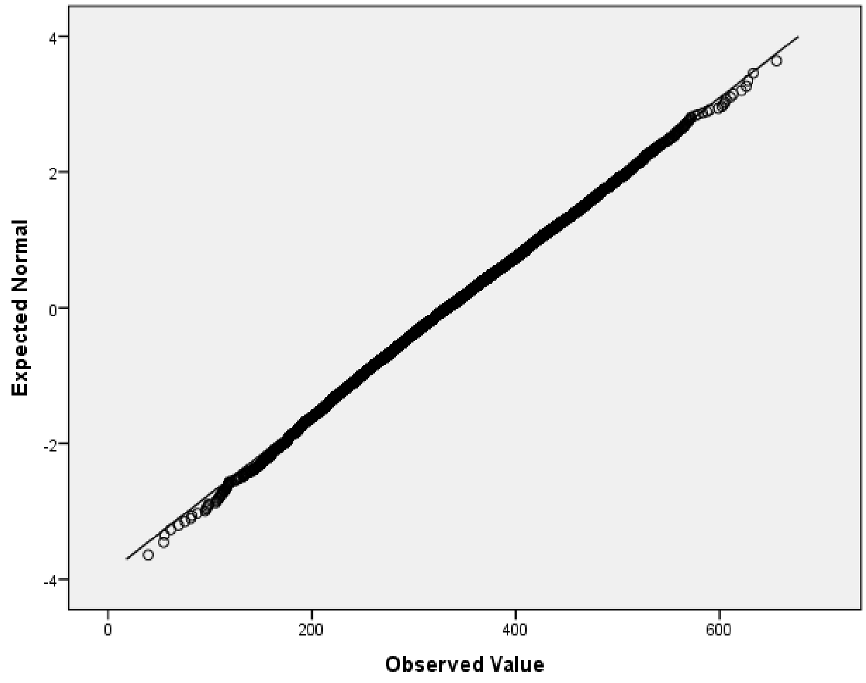

Figure G 1. Q-Q Plot of the predicted variable.

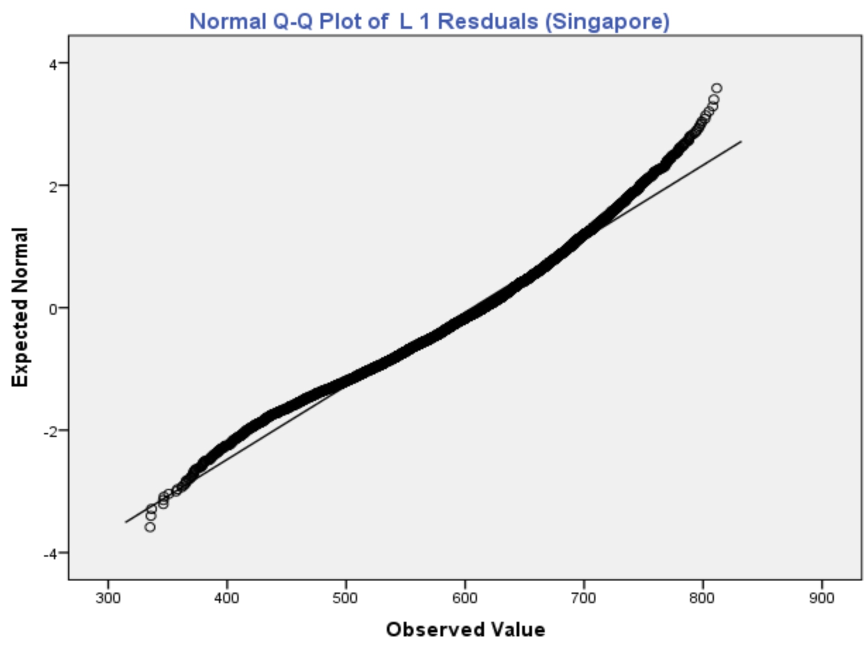

Figure G 2. Q-Q Plot of the predicted variable.