2024

Evaluating the Integration of a Mathematics Enhancement Programme into Jamaican Primary Mathematics Classes

Binns-Thompson, Shandelene Khadine Kedisha

https://pearl.plymouth.ac.uk/handle/10026.1/22053

http://dx.doi.org/10.24382/5145
University of Plymouth

[1] *E.g.* in the example of third party copyright materials reused in the thesis.
[2] In accordance with best practice principles such as, *Marking/Creators/Marking third party content* (2013). Available from: https://wiki.creativecommons.org/wiki/Marking/Creators/Marking_third_party_content [accessed 28th February 2022]

UNIVERSITY OF PLYMOUTH

EVALUATING THE INTEGRATION OF A MATHEMATICS ENHANCEMENT PROGRAMME INTO JAMAICAN PRIMARY MATHEMATICS CLASSES

By

SHANDELENE KHADINE KEDISHA BINNS-THOMPSON

A thesis submitted to University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Society and Culture

In Collaboration with
the Centre for Innovation in Mathematics Teaching

November 2023

ACKNOWLEDGEMENTS

I would like to acknowledge and express sincere gratitude to the people who made this study possible. Firstly, I must express deepest gratitude to the Centre for Innovation in Mathematics teaching for granting me a partial scholarship to pursue this course of study. I must secondly thank the participating schools, teachers, students, and parents who allowed me to work with them in their schools and classrooms. It was a profound privilege of mine to be able to implement a mathematics enhancement programme in these classes and observe the impact it had on students' attitudes and performance in mathematics and mathematics primary classrooms in Jamaica.

Heartfelt gratitude must be expressed to the members of my supervisory team, Professor David Burghes and Professor Garry Hornby who worked relentlessly with me throughout this research process. The support and guidance provided by my supervisors aided in fuelling my tenacity and will-power needed complete this study. The time that you have invested and the guidance that you have provided is invaluable and I am very grateful.

I would like to acknowledge the members of my family and relatives who supported me throughout this project. My husband, Raye and children Rajae and Reshaun who helped me create a home context that enabled me to sustain this study. My siblings, dad, stepmom, and friends who exhibited great confidence and belief in me. Finally, but by no means least I must acknowledge my creator who has sustained me and has given me the strength and the ability to complete this study.

AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

This study was partially financed with the aid of a studentship from the Centre for Innovation for Mathematics Teaching (CIMT) at University of Plymouth and carried out in coloration with CIMT.

Publications

Binns-Thompson, S.K.K., Hornby, G. and Burghes, D. (2021) 'Investigating the impact of a mathematics enhancement programme on Jamaican students' attainment', *Education Sciences*, 11(9), 516. DOI: https://doi.org/10.3390/educsci11090516.

Binns-Thompson, S. (2021) 'Teacher Subject Knowledge for enhancing learners' mathematical ability', in D. Burghes and J. Hunter (eds) *Mathematics Education for Sustainable Economic Growth and Job Creation*. 1st edn. London: Taylor & Francis Group, pp. 108-117.

Presentations and Conferences attended:

June 2022 Postgraduate Research Showcase, University of Plymouth, UK

June 2022 *Empowering Research* Doctoral College Conference, University of Plymouth, UK

April 2019 *International Mathematics Summit*, Mico University College, Jamaica, W.I.

March 2019 *Research Wednesday*, Mico University College, Jamaica, W.I.

Word count of the main body of the thesis: 58145

Signed: Shandelene Binns-Thompson

Date: November 21, 2023

ABSTRACT

Shandelene Khadine Kedisha Binns-Thompson

EVALUATING THE INTEGRATION OF A MATHEMATICS ENHANCEMENT PROGRAMME INTO JAMAICAN PRIMARY MATHEMATICS CLASSES

This embedded quasi-experimental research design examined the impact of an enrichment initiative entitled the Mathematics Enhancement Programme (MEP) on Jamaican students' performance and attitude towards mathematics. It identified teaching strategies for integrating the MEP into Jamaican primary mathematics classes. It investigated the impact of the MEP on teachers' pedagogical practices, and it identified the barriers to integrating the MEP. A sample of 331 students and 12 teachers were conveniently selected from three schools from three parishes in Jamaica for the intervention group. The comparison group consisted of 180 students and seven teachers conveniently selected from two schools in central Jamaica. The participating teachers were trained and certified in a mathematics Subject Knowledge Enhancement (SKE) programme prior the implementation of the MEP. The treatment involved teaching the Jamaican grades one and two mathematics standards using the MEP resources for nine months. Quantitative data collection over the school year included pre-tests, post-tests, and pre- and post- children's mathematics attitudinal surveys. The qualitative data was obtained through classroom observations and interviews. The quantitative data was analysed by means of descriptive statistics which involved the use of the 25th version of the statistical software (SPSS). Descriptive and in vivo coding were used to analyse the qualitative data which involved the use of QRS international's NVivo 12 qualitative software programme. A statistically significant impact and large effect size of the intervention was found, indicating that the MEP had a substantial impact on students' achievement and attitudes towards mathematics. Additionally, numerous teaching strategies were found to be effective for integrating the MEP. The findings also indicated there are aspects of the MEP that participating teachers thought were worth adapting and implementing in their practices. It was also found that there are barriers to integrating the MEP into Jamaican primary mathematics classrooms. Implications for designing enrichment programmes geared at addressing mathematics underperformance in Jamaica and other countries are discussed.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACROYMNS

BERA	British Educational Research Association
CAPE	Caribbean Advanced Proficiency Examination
CIMT	Centre for Innovation in Mathematics Teaching
CPD	Continuing Professional Development
CRT	Culturally Responsive Teaching
CSEC	Caribbean Secondary Education Certificate
CSP	Culturally Sustaining Pedagogy
EFA	(Jamaica) Education for All
GCSE	General Certificate of Secondary Education
GSAT	Grade Six Achievement Test
MEP	Mathematics Enhancement Programme
MKO	More Knowledgeable Other
MOEY	Ministry of Education and Youth
MOEYC	Ministry of Education, Youth and Culture
MMR	Mixed Methods Research
NCTL	National College for Teaching and Leadership
NCETM	National Centre for Excellence in the Teaching of Mathematics
NCTM	National Council of Teachers of Mathematics
NHP	New Horizon for Primary Schools
NESP	National Education Strategic Plan
PPP	Public Private Partnership
SKE	Subject Knowledge Enhancement
ZPD	Zone of Proximal Development

DEDICATION

This thesis is dedicated to the memory of my loving mother, Doreen Binns.

CHAPTER 1: INTRODUCTION TO THE STUDY

1.0 INTRODUCTION

> From bustling townships and cities to the 'irie' countryside, we are a people of tremendous God-given talent and potential. Out of diverse hardships we remain strong and deeply spiritual. Jamaica, an island gem basking in brilliant sunshine, where cool waters cascade from the mountains to the fertile soils of the valleys below. (Planning Institute of Jamaica, 2009, p. vi)

This quote paints a synoptic picture of the Island where this research was conducted. It also aids in communicating that the nation's desire to strive for excellence persists amidst the hardships endured. Understanding the historical and philosophical background of the participating country will aid in establishing the context of this research. This chapter starts by providing an overview of Jamaica and Jamaica's history. It details the historical journey of education in Jamaica and provides a background of the nation's mathematics education. It also describes the central aim and rationale of this study. Finally, the guiding research questions are stated in this chapter.

1.1 HISTORICAL BACKGROUND OF JAMAICA AND EDUCATION IN JAMAICA

1.11 Overview of Jamaica

Located in the Greater Antilles is the beautiful island of Jamaica; It is the third largest Caribbean Island and the largest English-speaking Island in the Caribbean (Murphy, 2004; Jamaica Overview, 2020). Jamaica is '4243 square miles (10993 square kilometres) in size and has a population of 2.8 million' (Jamaica Overview, 2020, p. 1). Additionally, Jamaica measures 146 miles at its widest point (from east to west) (Murphy, 2004, p. 1) and it is located 90 miles south of Cuba and 560 miles southeast of Florida (Palmer, Hermond, Gardiner, 2014, p. 35). The island is divided into three counties: Cornwall, Middlesex, and Surrey (Overview of Jamaica, 2020, p.1). The three counties of Jamaica collectively consist of a total of fourteen parishes, each with their own distinguishing features that make them unique. The 14 parishes of Jamaica are: Kingston, St. Andrew, St. Catherine, Clarendon, Manchester, St. Elizabeth, Westmoreland, Hanover, St. James, Trelawny, St. Ann, St. Mary, Portland, and St. Thomas. The capital of Jamaica is Kingston which is located on the island's southeast end (Holness, no date; Overview of Jamaica, 2020).

As recalled by Ntreh (2020), Jamaica's name was derived from the Arawak word 'Xaymaca' which means 'land of wood and water'. Jamaica is an island that is known to have a very rich and varied landscape; its terrain boasts towering mountains, expanses of lush vegetation as well as long stretches of clear sandy beaches (Overview of Jamaica, 2020, p.1). This verdant island also features a mountain ridge which is 7, 402 feet high and peaks at Blue Mountain (Murphy, 2004).

'The people of Jamaica have emerged from a historical process in which peoples of all the continents were brought together within a well-defined social hierarchy. The vast majority are of African descent, but there are well established, but small, Indian, Chinese, Arab, and European communities as well' (Murphy, 2004, p. 1). The main ethnic groups of the Jamaican population consist are of 90% African descent, while Whites, East Indians, mixed race and others make up the other 10%; Jamaica's culture is a synthesis of all the cultures under its umbrella of ethnic groups (Palmer, Hermond and Gardiner, 2014). The popular culture is heavily influenced by its African heritage, while formal behaviour is unmistakably British in style (Murphy, 2004).

As outlined by The World Bank in Jamaica (2020), Jamaica is classified as an upper middle-income country whose economy is heavily dependent on tourism. Jamaica has long been a powerful force on the global scale and is widely known for its Reggae music and associated genres such as dub, mento, ska and dancehall (Word Music Network, 2013). Jamaica is recognized as the birthplace of the Rastafarian Religion

(Dahir, 2017) and it is internationally prominent in sports such as cricket and athletics (Wood, 2014). Jamaica's mixed cuisine is a spicy and colourful one that includes ackee and saltfish, rice and peas, jerk chicken, fish and pork, curried goat, pepperpot soup, roasted yams, banana fritters, salads, fruits, and exotic desserts. A large part of the country's attraction is also captured in its art and crafts, influenced by African, Indian, European and Arawak cultures, often depicting life and landscape, with Jamaican paintings that feature bright and bold lines (Murphy, 2004).

1.12 Overview of Jamaica's History

Jamaica's history may be classified as a rich and vibrant one that inspires us to move forward as a nation. The history of Jamaica speaks to experiences of hardship and prosperity; and the growth and determination of a people (Jamaica Information services, no date). A venture into Jamaica's history reveals that Jamaica was first inhabited by the Native American tribe, the Arawak-Indians, commonly called the Tainos. The island was then invaded by the Europeans (Spanish) near the end of the 15th century. The invasion by the Europeans was based on plunder and trade, which decimated the Arawak-Indians leaving their primitive communal societies destroyed (Oxfam Digital Repository, no date). This invasion subsequently gave birth to slavery and the slave trade which lasted for nearly four centuries. In the quest to increase and keep replenishing workers, slaves were brought in from Africa to work and grow sugar cane. In 1655, the British took control of the Island from the Spanish and it became a British Colony (Jamaica Information Service, no date). Upon the arrival of the English, the Spanish fled but firstly they freed their slaves. The slaves escaped into the mountains and later formed the independent Maroon Settlements. 'The Maroons fought for their 'rights' for most of the seventeenth and eighteenth centuries, using a form of guerilla warfare which baffled most of the forces sent to subdue them' (Oxfam Digital Repository, no date, p. 10).

In 1834 slavery was abolished and the country was emancipated in 1838 (Oxfam Digital Repository, no date; Jamaica's History & Background, no date). Following emancipation, the ex-slaves had no land, finance, or basic tools to start a new independent life and were forced to work for subsistence on the plantations and farms captured (or squatted), often poor-quality lands (Oxfam Digital Repository, no date, p.10). Agricultural activities were a central part of the economic activity and livelihood for most Jamaicans for several years leading up to independence in 1962. The nation established itself as one of the leading bauxite producers in the world during the 1960s (Dennis, 2014).

In the 1900s, Jamaica gradually gained self-government and control from Britain becoming a fully independent country in 1962 (Brief History of Jamaica, no date). Upon gaining political independence, Jamaica was still underdeveloped, dependent and poverty stricken (Oxfam Digital Repository, no date). In the mid 1970s, increases in oil prices, expansionary fiscal policies and entrenched labour unions resulted in unemployment and recession. By the 1980s, major Jamaican sectors were government owned, yet its economy was generally defined as free enterprise. From the 1990s to present, Jamaica's economy has weathered many storms and like several other developing countries has looked to external sources like the IMF for financial support (Oxfam Digital Repository, no date; Economy, no date). Currently, Jamaica has more job and training opportunities available for its people yet there are Jamaicans who struggle to find employment and are living in poverty. To grow and prosper, Jamaica needs to develop the skills needed for the workforce of tomorrow (Van Trotsenburg, 2019).

1.13 Jamaica's Education System

Jamaica's education system is best explained and understood in the context of the island's colonial history (Education in Jamaica, no date). Prior to the nation being emancipated, Jamaica had miniscule formal and cohesive education for whites and no system for educating its indigenous people and ex-slaves. During this period the sons of wealthy white planters were sent back to the 'mother country' for schooling while others were tutored at home (Education in Jamaica, no date; Jamaica History and background, no date). The less opulent planters sent their sons to one of the free schools that were built through donation from wealthy planters and merchants (Gordon, 1963). Among the free schools that were established by varying trust funds are Wolmers School, Mannings School, Russeas High School and Titchfield High School which today remain as high-ranking institutions in Jamaica (Five Oldest High Schools in Jamaica, 2015). The curricula used in the free schools were mirrored on those used in Great Britain and were geared at offering a classical education to young men that would enable them to develop the requisite skill sets needed to take their place in society. The year 1770 marks the inaugural mention of educating girls in Jamaica's history. It was in this year that the curriculum at Wolmer's Free School was tailored to enable the education of girls in Jamaica. The modified curriculum at Wolmer's Free School was structured to equip girls with the indispensable skill sets needed to run a home and to be employed as seamstress and mantuamakers (Education in Jamaica, no date; Jamaica History & Background, no date). It was during this period that some girls were also able to be trained and procured jobs as teachers. (Hamilton 1997, cited in Jamaica History & Background, no date).

Educational opportunities for indigenous people and slaves prior to emancipation were mainly non-existent in Jamaica (Gordon 1963; Jamaica History & Background, no date). Only a few slave children were privy to educational opportunities at plantation schools that were established by foreign missionaries (Education in Jamaica, no date; Jamaica History & Background, no date). The education offered by foreign missionaries was based on religion and virtues of submission (Education in Jamaica, no date). In 1834, the Emancipation Act was enforced and for the first-time indigenous people and slaves were afforded the opportunity for mass schooling. The Emancipation Act also provided for the education of ex-slaves, which was formally supported by the Imperial Government and through the Negro Education Grant. For the first 2 years, the Negro grant was issued to religious groups solely for constructing schools (Hunte, 1976).

Morrisons and Milner (1995) who were cited in the article, Jamaica's History and Background (no date) posited that once slavery was abolished in 1834, education was viewed as an important way to integrate ex-slaves into the colonial economy and to ensure a peaceful lower class. Following emancipation, the missionary societies developed an elementary education system for newly freed slaves (Jamaica's History & Background, no date). Early education during this period was used as a medium to prepare children for gaining employment as estate workers. Elementary education was however 'focused on reading, writing and arithmetic with some religious training and occasional geography and history instructions' (Jamaica History & Background, no date, pp. 1-2). Additional training in agriculture and other manual arts were offered to boys while girls were trained in sewing and domestic science (Education in Jamaica, no date). By 1953, about 75% of children of primary school age were enrolled in school. In contrast, approximately 5% of the population had access to secondary education (Miller, 2018, pp. 207-208).

As outlined in the article Education in Jamaica (no date), much of the educational reform and restructuring in Jamaica from the 1940s until independence in 1962 was hurried and structured to appease the interests of Great Britain. It was during this period that Jamaica started to prepare for educational independence by establishing its own Ministry of Education and developing a national education policy in 1953 (Education, no date; Education in Jamaica, no date). This national policy expanded the scope of education and redefined educational priorities.

The norm following independence in 1962 was for children to attend infant and elementary school; At the end of elementary school, only a few children passed the common entrance examination (today called Primary Exit Profile) attended high school; those who got scholarships and those whose parents could afford to pay the tuition fees (Tyson, 2012). Not many persons could afford these fees. It was not until the 1970s that education became common for Jamaicans; but there still existed inequality in the system since access to education continued to be heavily skewed towards higher income households and light-skinned elite in the country's capital, Kingston (Education, no date; Trines, 2019). The limited availability of schools especially beyond primary level education and the elitist curriculum intensified class division in post-colonial society.

During the 1980s, educational provisions declined and 'the poorer strata in the society were generally more seriously affected by the deteriorating provision' (Oxfam Digital Repository, no date, p. 35). Teachers had limited or no resources to work with, enrolment in primary schools declined and there were high levels of grade repetitions and school dropouts (Oxfam Digital Repository, no date). During the late nineteenth century, the secondary education system in Jamaica grew significantly and higher education began to expand in earnest. However, it was not until the mid-20th century, when the British granted Jamaica greater self-governance, that a less segregated mass education system began to emerge on the island (Trines, 2019).

As suggested by Miller (2018) reforms for the Jamaican educational system were further developed in the 20th century as a means of addressing the issues impacting education in Jamaica. 'Initially the reforms focused on building more schools, expanding existing schools, training more teachers, and lowering the age of admission from seven to six years. Overtime the reforms were expanded to include provisions for children with varying degrees of disability' (Miller 2018, p. 207). Currently, Jamaica is transforming its education system and building the capacity of a network of institutions to improve the quality of its educational services (Hastings, 2015). As outlined in the Jamaica Education for All (EFA) report, significant changes have been taking place in the education system since 2000 (Ministry of Education, 2014). The report includes changes being implemented to improve the efficiency and effectiveness of the education system as it prepares its citizens to meet the challenges of the 21st century. Changes in Jamaica's education system are detailed in four of the nation's major policy documents:

- The White Paper, Education: The Way Upward – A Path for Jamaica's Education at the Start of the New Millennium, 2001 (Ministry of Education, 2001)
- The Task Force on Education Reform, 2004 Jamaica Report and the resultant Education Transformation Programme (Davis, 2004)
- The National Education Strategic Plan (NESP) 2011-2020 (Ministry of Education, 2012)
- Vision 2030 Jamaica National Development Plan (Planning Institute of Jamaica, 2009).

The policy framework of the white paper on education sought to address the challenges within the sector (Ministry of Education, 2001). This policy also addressed diversity in schools with the aim of aligning education in Jamaica to changes occurring globally. The vision of the Task Force on Education stated that:

> - Each learner will maximise his/her potential in an enriching, learner-centred education environment with maximum use of learning technologies supported by committed, qualified, competent, effective, and professional educators and staff.
> - The education system will be equitable and accessible with full attendance to Grade 11. Accountability, transparency, and performance are the hallmarks

> of a system that is excellent, self-sustaining, and resourced and welcomes full stakeholder
> participation. The system produces full literacy and numeracy, a globally competitive, quality workforce and a disciplined, culturally aware, and ethical Jamaican citizenry. (Davis, 2004, p. 11)

To fulfil this vision, the EFA report recommended: the construction of new schools; the upgrading of all existing schools to world-class standards and the elimination of the shift system (where a school caters for two entirely separate groups of learners during a school day); upgrading of curriculum teaching and learning support systems with particular focus on literacy and numeracy; exposing school boards and principals to new concepts of governance with an emphasis on leadership and administration; building community participation and ownership of schools to influence positive behavioural changes and stimulate a higher level of involvement; and modernization of the Ministry of Education to become a Policy Ministry (Ministry of Education, 2014).

The National Education Strategic Plan (NESP) 2011-2020 detailed the sectors macro objectives which include providing equitable access and/or attachment to a high-quality education system for all Jamaican children ages 3-18; improving learners' performance across the formal education system; providing resource-rich environment supportive for all learners at all levels in the public education institutions by 2020 and enabling all learners in the education system to manage challenges and achieve their developmental goals through integrated curriculum offerings (Ministry of Education, 2012, p. 1). One of the four strategic objectives of the National Development Plan, Vision 2030 Jamaica, is to empower Jamaicans to achieve their fullest potential through personal and national development through education and training (Planning Institute of Jamaica, 2009). To attain this goal, the following strategies were proposed:

- Ensure that every child has access to early childhood development
- Enable a satisfactory learning environment at the primary level
- Ensure a physical environment in all schools that is safe and conducive to learning at all levels of the school system
- Ensure that adequate and high-quality tertiary education is provided with emphasis on the interface with work and school

- Expanding mechanisms to provide access to education and training for all including unattached youth
- Promote a culture of learning among the general populace.

(Planning Institute of Jamaica, 2009, p. 69)

Formal education in Jamaica currently falls under the portfolio of the Ministry of Education, Youth, and Information (Trines, 2019). The Ministry is guided by the philosophy 'Every Child Can Learn, Every Child Must Learn', with the vision,

> 'A customer-centred, performance-oriented education system producing globally competitive, socially conscious Jamaican citizens' *and the mission* 'to provide strategic leadership and policy direction for quality education for all Jamaicans to maximize their potential, contribute to national development and compete effectively in the global economy, as it pursues its developmental goals for the nation'. (Education in Jamaica, no date, p. 3)

The structure and content of the education system in Jamaica has gone through several stages of development over the years (Education in Jamaica, no date). Now at age three, children enter early childhood institutions, then at age 6 they enter primary schools; at the end of primary schools, students take the Primary Exit profile Examination, which acts as the entrance examination for students to access secondary education. At the end of High school students take the Caribbean Secondary Education Certificate (CSEC) Examinations in their course of studies. The CSEC examination is equivalent to the General Certificate of Secondary Education (GCSE) examination in England. Success in at least 5 of the CSEC examinations will allow students to further their education with Mathematics and English A being Mandatory (Trines, 2019). After success is attained in CSEC, pupils can pursue courses at the 12^{th} grade level and take the Caribbean Advanced Proficiency Examination (CAPE), equivalent to the English based A level examination, and/or attend tertiary or vocational institutions (Education in Jamaica, no date; Trines, 2019).

1.14 Mathematics Education in Jamaica

Mathematics is an exciting and creative subject that evolved out of human needs to understand and manage circumstances and resources and solve problems (Pope, 2010 p. 6). As put forward by the Ministry of Education, Jamaica, mathematics is a well-established discipline that is universally accepted as a core subject, and that occupies a central place in education (Ministry of Education, 2011, p. 9). Mathematics is a global language (Pope, 2010, p. 6), that has its own inescapable beauty and when taught well can engage and delight students (Ministry of Education, 2011, p. 9). Mathematics is also instrumental in helping pupils understand how the world works, while at the same time exposing them to some of its unanswered mysteries; Mathematics teaches students how to reason logically, it helps them to develop their critical thinking skills and provides them with the tools needed to function effectively in their environment. Harris and Bourne (2017) describes mathematics as: one of the most important subjects taught in all primary schools; In Jamaica, students learn mathematics every day, for half an hour of the five school days. This view was endorsed by Bourne (2019) who detailed that mathematics is an important component in the formation of the educated person. He added that mathematics education should reflect the goals of education in a dynamic society.

However, there is a crisis of teaching and learning in Jamaica and this crisis is affecting mathematics education (Bourne, 2019, p.8). As outlined by the Ministry of Education (2011), there is concern about the unsatisfactory performance of students in mathematics at all levels of the education system in Jamaica. For decades, the performance of Jamaican students in mathematics has been below expectations (Bourne *et al.*, 2017, p. 25). Poor performance in Jamaica is recognized when an individual has not successfully passed an external examination or has received a score of less than 50% on an internal test (Harris and Bourne, 2017, p. 9). Evidence of students' underachievement in mathematics at the primary level is reflected in the statistics of their performance on primary exit examinations (Bourne et. al, 2017, p. 25). The data shows that over the decade (2009 – 2018), Jamaican primary school students passing the mathematics primary exit examination fluctuated between 40% and 63% (Bourne, 2019, p. 9; Ministry of Education, Youth and Culture, no date).

'The already established position that mathematics encompasses most areas of people's lives and having splintered primary and secondary school curricula in Jamaica accounts for why students are not seeing the integration of the various subjects, and accounts for the low performance in mathematics compared with high performances in other subject areas such as Principles of Accounts, Social Studies, and Principles of Business' (Bourne, 2019, p.9). The Ministry of Education (2011, p. 11) is of the belief that a challenge to mathematics education in Jamaica is that the subject is often presented as an isolated stand-alone discipline which is taught through procedures and rules that should be followed. Evidence provided by the National Education Inspectorate (2013) indicates that attainment in mathematics is negatively impacted by the incapacity of instruction to meet the needs of all learners, the weak mathematics foundation that is laid for students, and the ineffective instructional leadership observed in various institutions.

'Is there something amiss with the teaching-learning process that is accounting for the underperformance of Jamaican candidates in mathematics' (Bourne *et al*., 2017, p. 26)? Jamaica's Ministry of Education identified that the way in which students are engaged in learning mathematics in the classroom as a significant contributing factor to the low levels of students' performance in the subject (Ministry of Education 2011, p.11). This view has been supported by Harris and Bourne (2017) who posited that poor methods of teaching negatively affect pupils' academic performance.

In Jamaica mathematics is often taught with a high level of abstraction. Abstraction hampers students' ability to develop an awareness of the applicability of mathematical concepts and ideas to everyday life and experiences (Ministry of Education, 2011, p.11). Bourne *et. al* (2017) suggested that teaching that is set at the same level of abstraction is a by-product of passive teaching which allows students to perform within the limits of resources available to the teacher and involves reducing mathematical content to its simplest component.

Coupled with the issue of teaching mathematics abstractly, many Jamaican teachers have been teaching to prepare students for examinations. Bourne (2019) argued that teachers should discontinue the practice of teaching for examinations since this approach to teaching may not be the most effective. To the students' disadvantage, some Jamaican teachers teach their stronger areas of mathematics but avoid teaching areas that they are weak in (Harris and Bourne, 2017, p. 7). Bourne (2019) is of the opinion that this practice will allow students to become weak in the areas of mathematics avoided by teachers, which will subsequently have a negative impact on their performance in mathematics.

Additionally, students' underachievement is influenced by the inappropriate deployment of teachers in areas in which they lack training. Also, although the fact that many Jamaican teachers have upgraded their qualifications, they have not done so in the teaching of mathematics but are assigned to teach the subject (Crossfield and Bourne, 2017). Conclusively, it was maintained that the holistic quality of teachers impacts students' attainment on exit examinations.

Bourne, *et al*. (2017) are of the opinion that if mathematics is to be effective in developing critical thinking and problem-solving skills then it must be taught, especially in the early years, in a manner that makes it developmentally appropriate to learners in terms of their individual readiness, cultural background and emotional profile. It has been argued that the learners' ability to appreciate the worth of mathematics formally and informally is a function of the awareness they have experienced in their classroom setting (Chinnappan, 2008, cited in Palmer, Hermond and Gardiner, 2014). In support of this view Crossfield and Borne (2017) suggest high quality professional development activities and mathematics programmes that focus on content knowledge and are intended to improve the quality of delivering mathematics concepts as factors to consider in the quest of improving attainment in mathematics.

1.2 AUTHOR'S ONTOLOGICAL AND EPISTEMOLOGICAL STANCE

Being born and raised in a developing country coupled with my full experiences of life will play a pivotal role in how my research will be framed. My belief system which has developed from a combination of my life's experiences and the historical background of my home country will form my ontological positions. A detailed overview of how my ontological position developed my epistemology is outlined below.

My own experiences of life growing up in Jamaica can be linked back to the 1980s. As a child born and raised in a developing country, I was taught that education was the only way out of poverty. Additionally, education was presented to me as a road map that will aid in navigating Jamaica towards gaining and sustaining full self-reliance and subsequently becoming recognized for its worth in the global sphere. In fact, as children we would often recite the following verse 'Labour for learning before you grow old, for learning is better than silver and gold; silver and gold will vanish away, but a good education will never decay' in primary school. As a child, reciting this memory verse was just a routine for me. Life's experiences, however, have taught me that within that memory verse lies a moral lesson. I have been made to realize that this memory verse was teaching us as children that it is better to gain a firm education than to acquire ‘fly-by’ material things, since material gains are not self-sustainable, but knowledge acquired will positively impact lives and be the driving force to help a nation such as ours to evolve and compete in a global market.

My passion for change and becoming an agent of change has caused me to pursue a career in education. Being a Jamaican educator with over 15 years of experience, I am quite aware of the daunting issues that plague our educational system. One of the biggest issues faced by Jamaican educators is having limited access to educational resources that would aid students in realizing their fullest potential. This problem stems from the fact that the country is still struggling financially. Evidence of this has been recorded by Dennis (2014) who purports that Jamaica’s cumulative stagnation has caused many to remain in poverty and has constrained the rate of development of human and general productive capacities and also places a cap on how much the government can invest in education.

Another issue that I have observed is that many educators resort to implementing basic traditional teaching practices in their teaching and learning discourses. Only a few Jamaican teachers are exposed to effective practices in the teaching and learning of given subject matter. Only a fraction of those exposed are equipped with the requisite skill set and resources needed to effectively adapt and implement these practices. Amidst the obvious struggles that the Jamaican educational system faces, the Ministry of Education is working relentlessly to invest more in education as evidenced in the partnerships formed with private companies/foundations geared at filling these gaps. As put forward by Smith (2018), the government of Jamaica remains focused on building greater public-private partnerships (PPP) as it works to achieve economic and educational growth. This, I believe is a silent revolution.

I agree with the words of Van Trosenburg (2019, p. 1) who is of the opinion that for 'this silent revolution to continue and bring greater prosperity to all its people, Jamaica will need to invest more in its people to build human capital'. One way in which Jamaica can achieve this is through investing more in education. In addition to this silent revolution, Knight and Rapley (2007, p. 4) recommended 'that future changes to Jamaica's education policy should include:

- More resources should be put into primary education
- The quality of teaching at primary and secondary levels should be augmented'.

As an educator with over 15 years of experience, I have worked both as a teacher of Mathematics and mathematics teacher educator. It is clear to me that students learn better when they can relate to the concepts/knowledge being developed in the teaching and learning discourse in which they are engaged. Students also tend to excel more when avenues are created for remediation and enrichment. Enrichment programmes promote higher levels of thinking and creativity in a subject and allow students to explore that subject in depth (Fox, 1979, cited in Kim, 2016). Additionally, enrichment is a way to meet the students' needs for self-activity and to further stimulate their interest in their area of study (Feng, 2006); which subsequently impacts academic performance.

1.3 BACKGROUND CONTEXT OF THE STUDY

Jamaica seeks to develop an education and training system that produces well-rounded and qualified individuals who will be empowered to learn for life and productively function in society and be competitive in a global context (Planning Institute of Jamaica, 2009). As Jamaica strives to take its place within a fiercely competitive and highly globalized marketplace, its school graduates must be equipped with the requisite mathematical knowledge needed to access the kinds of jobs that are emerging and compete internationally (Ministry of Education, 2013). This vision is, however, hampered by the underachievement that still prevails in Mathematics in Jamaica despite efforts to improve mathematical instruction. This view has been endorsed by Buddo (2017) who purports that the school subject of mathematics in Jamaica has always presented challenges for learners at all levels of the educational system. Since the 1980s, the Jamaican Ministry of Education has embarked on various projects or initiatives to address the poor performance in mathematics by students who sit the national assessment tests or the Caribbean Examination Council's Secondary Education Certificate (CSEC) Examination. However, despite these interventions, the performance continues to be below expectations. This is evident in the findings recorded in Tables 1.1, 1.2 and 1.3 which reveal that, for the ten-year period 2009 – 2018, students' performance in grade four numeracy examination, the GSAT mathematics examination and the CSEC mathematics examinations have fluctuated between a low of 33.2 percent and a high of 66 percent.

Year of Examination	National Mastery Average (%)
2009	45
2010	41
2011	49
2012	54
2013	59
2014	57.6
2015	65.7
2016	58.9
2017	66
2018	66

Table 1.1 Performance on the Grade 4 Numeracy Test for the Period 2009 - 2018 (Ministry of Education and Youth (MOEY), no date)

Year of (GSAT) Examination	National Average GSAT (%)
2009	53
2010	57
2011	62
2012	63
2013	61
2014	60
2015	56
2016	58
2017	62
2018	61

Table 1.2 Jamaican Grade Six Achievement Test (GSAT) Mathematics Results for the Period 2009 – 2018 (MOEY, no date)

Year of (CSEC) Examination	Percentage Pass in Mathematics
2009	40
2010	39.5
2011	33.2
2012	31.7
2013	42.2
2014	55.5
2015	62
2016	44
2017	50.2
2018	46.5

Table 1.3 Caribbean Secondary Examination Certificate (CSEC) Results for Jamaican Candidates for the Period 2009 – 2018 (MOEY, no date)

The unsatisfactory performance of students in mathematics and the low levels of numeracy exhibited by students and graduates of the Jamaican educational system has been a cause of much concern for stakeholders in education in the private and public sectors (Ministry of Education, 2013). As put forward by Jamaica's mathematics and numeracy policy (2013), the Ministry of Education, Youth and Culture (MOEYC) recognised that the nature of teaching and learning is one factor contributing to the poor performance and underachievement in mathematics. The policy has identified effective teacher pedagogy as an important tool that can be used to promote high levels of numeracy and enable the overall mathematical development and achievement of students. It was clearly outlined in the policy that experiences provided in the classroom should be geared towards the development of skills which enable not only meaningful use of the ideas learnt but also the development of problem-solving and critical thinking skills. This cannot be achieved, however, unless focus is placed on the quality of mathematics teaching. The National Mathematics Policy (2013) suggested that mathematics lessons should be focused on facilitating the development of problem-solving skills so that mathematics teaching at all levels of the educational system will facilitate the development of analytical, reasoning and critical thinking skills. One way to achieve this goal is to identify and adapt effective practices observed in mathematically high-performing countries.

The Mathematics Enhancement Programme (MEP), which was pioneered by Professor David Burghes, is based on the premise of proven effective practices observed in mathematically high-performing countries such as Hungary, Poland, Czech Republic, Japan, Singapore and Finland (Bughes 2000; Burghes 2012). The structure of the MEP could help the Jamaican Educational System address some of the issues it faces in Mathematics. The MEP has been shown to positively impact students analytical and logical thinking skills (Smith, 2012), skills that are needed for success to be attained in mathematics. Additionally, the MEP has been shown to positively impact performance in mathematics (Burghes 2000, Burghes 2012, Hazell 2012; Smith 2012). The MEP because of its effectiveness in positively impacting attainment in mathematics in first world countries was identified, adapted for, and integrated in Jamaican mathematics primary classrooms.

1.4 RESEARCH AIM

The study is aimed at investigating the effect of integrating the MEP into Jamaican Primary Mathematics classes. This was done to examine the impact the integration of the MEP has on students' performance in mathematics. It will explore the teaching strategies that can be used to integrate the MEP into Jamaican mathematics classes. The study will also seek to identify the factors to be considered when integrating the MEP, the barriers associated its incorporation and the impact the integration has on students' attitudes and disposition towards mathematics education.

1.5 RATIONALE FOR THE STUDY

For years the school subject of mathematics has presented a challenge for learners at all levels of the Jamaican educational system. The Ministry of Education has designed and implemented several intervention programmes to address this issue, yet students continually underperform in existing examinations (Buddo, 2017). As a nation, it is realized and acknowledged that in order for economic growth to take place and for Jamaica to take its place in the fiercely competitive and highly globalized marketplace, its school graduates must be equipped with the requisite mathematical knowledge (Ministry of Education, 2013). This dream of Jamaica becoming globally competitive is however hampered by the low academic attainment in mathematics at all levels of the educational system. Evidence of this was noted in the Ministry of Education, Youth and Information (2017) Chief Inspector's Report which disclosed that approximately 79% of the nation's pupils are performing below average in mathematics. The government of Jamaica recognizes that the standard of mathematics education needs improvement in order to raise the levels of numeracy and attainment in mathematics of all students in

Jamaica (Ministry of Education, 2013). This policy also outlined the following as practices that teachers of mathematics should enforce:

- Mathematics lessons should be focused on facilitating the development of:
  - ✓ conceptual understanding,
  - ✓ computational fluency and
  - ✓ problem-solving skills' (Ministry of Education, 2013, p. 10).
- Mathematics teaching at all levels of the educational system should:
  - ✓ stimulate the learner' curiosity by providing opportunities to explore number patterns and their relationships;
  - ✓ facilitate the development of analytical, reasoning, and critical thinking skills;
  - ✓ develop a flexible approach to the learning of mathematics so that learners will be encouraged to develop their own strategies for calculating and for problem-solving which they are able to explain to others;
  - ✓ encourage mental processes, including the use of mental imagery, as a tool for exploring mathematical situations;
  - ✓ help learners to develop a spirit of inquiry;
  - ✓ provide ample opportunity for the development of mathematical processes such as conjecturing, generalizing, justifying and proving through the exploration of open-ended problems and investigations;
  - ✓ adopt an investigative approach to teaching;
  - ✓ adopt a good balance of whole group interactive teaching, individual work. (Ministry of Education, 2013, pp. 11 – 12)

The structure of MEP lessons and its required teaching styles adequately address the suggested practice outlined by the Jamaica's National Mathematics Policy Guidelines.

Another factor that negatively affects Jamaican students' performance in mathematics is their attitude and disposition towards the subject. Hylton (2022) believes that the major issue with mathematics literacy in Jamaica is students' attitude and disposition towards the discipline. She notes that some students are of the belief that the mastery of mathematics is innate, and students have subsequently formed fixed mindsets towards mathematics. Evidence of these fixed mindsets are echoed in students' comments which include; 'I can't do maths', 'mathematics is not in my genes' and 'I am a failure'. The responses of teachers are crucial for changing this mindset. The pedagogical practices employed by teachers often influence the kind of attitude students develop towards mathematics; a lacklustre lesson will lead to disengaging and boring students but when a teacher instils excitements and passion in the classroom, students will mirror this passion (Hylton, 2022).

Healthy learning cannot take place when students are apprehensive about a subject. Teachers of mathematics need to take students to their comfort zones by giving them familiar tasks to build their self-confidence before introducing new concepts. The progress students make in mathematics is strongly dependent upon fundamental knowledge. It is therefore important for students to master fundamental knowledge before moving on to new knowledge (Hylton, 2022). This will help to build students' confidence in mathematics and subsequently aid in fostering the development of positive attitudes towards the subject. Additionally, to foster the development of positive attitudes in, it is recommended that mathematics teaching should aid in building students' confidence to use mathematical ideas, principles and procedures, and help students see the applicability of mathematics in day-to-day life (Ministry of Education, 2013). Jamaica's national mathematics policy also recommends that the teaching of mathematics at all levels of the educational system should: provide the learning environment in which learners will be able to develop a sense of confidence in working within a mathematical environment; enable learners to see mathematics as an interesting and stimulating subject that can be enjoyed and facilitate the development of positive attitudes towards mathematical engagement and activities.

In line with these recommendations, the MEP was adapted, tailored, and integrated into Jamaican Primary Mathematics classrooms. The MEP, which was developed based on effective practices of mathematical high-performing countries (Burghes 2000; Burghes 2012) has proven to be effective in helping students develop their analytical and problem-solving skills (Burghes 2000; Burghes 2012; Hazell 2012; Smith 2012). Evidence of this was documented by Smith (2012), who stated that after the implementation of the MEP, students' critical and logical thinking improved and their development and use of mathematical language were significant (p. 59). Studies have also shown that students' attainment in mathematics improved after the implementation of the MEP (Burghes 2000; Burghes, 2012; Hazell 2012; Smith 2012). It is necessary to start this integration at the primary level of the education system since the development of any structure begins at the foundation. Spelke (2000) purports that, from birth one's brain is equipped with domain-specific core knowledge systems which allows for initial representations and reasoning. In support of this view, Fritz-Stratmann (2013) maintained that based on the efficiency of the core knowledge system for numerosities, children acquire first solid mathematical concepts when they start school, since they already have a 'history' of mathematical learning and are equipped with profound mathematical knowledge. It is therefore important that at this formative stage where students are exploratory, and their analytical skills are optimal that they be introduced to the Mathematics Enhancement Programme (MEP).

The MEP was found to be effective in positively impacting students' attitude and performance in mathematics and its key features can potentially address some of the recommendations of Jamaica's Ministry of Education for mathematics education. It is however important to consider the impact the implementation of a new initiative will have on an existing educational structure and its main stakeholders. Jamaica's educational system emerged over the years, but it is still plague with different issues. Limited access to resources is one of the main issues that plagues Jamaica's educational system (Hasting, 2015; Oxfam Digital Repository, no date; Trines, 2019). Also, Jamaican teachers of mathematics have a routine way of teaching. Mathematics is commonly taught with a great level of abstraction and in some cases mathematics lessons are structured to prepare students for examinations (Bourne, 2019; Harris and Bourne, 2017; Ministry of Education, 2011). Additionally, some Jamaican teachers of mathematics were not trained in mathematics education (Crossfield and Bourne, 2017).

It is important to consider how the current issues that wave over Jamaica's mathematics classrooms will impact the integration of a new enrichment initiative. It is based on this premise that this research also seeks to examine the potential barriers to integrating the MEP into Jamaican primary mathematics classes.

The MEP is known to positively impact students' critical and analytical skills and performance in Mathematics (Burghes 2012; Hazell 2012) and subsequently positively impact performance in Mathematics (Burghes 2000; Burghes 2012; Hazell 2012; Smith 2012). It is however important to examine the impact of the MEP on the existing structure of Jamaica's primary education. In light of this, the current study will seek to evaluate the integration of the MEP into Jamaican Primary Schools.

1.6 RESEARCH QUESTIONS

The study was guided by the following research questions:

1. How does the implementation of the MEP impact students' performance in mathematics?
2. How does the implementation of the MEP impact students' attitudes and disposition to mathematics education?
3. What teaching strategies are used in implementing the MEP in mathematics classes?
4. What do teachers consider as the most effective teaching strategies for implementing the MEP in mathematics classes?
5. What do teachers consider to be the barriers to incorporating MEP resources and teaching strategies in Jamaican primary classrooms?
6. Which aspects of the MEP do teachers think they will adapt and implement in their own practice?

1.7 OVERVIEW OF THESIS

This thesis is presented in five chapters. This chapter has provided an overview of the history and educational background of the country where the research took place, the ontological and epistemological point of view, the background to the study, the research aim and the rationale. In Chapter two relevant research literature is reviewed comparing the teaching of mathematics in a traditional classroom with teaching mathematics in an enriched classroom. The role of problem-solving and mathematical thinking in mathematics enrichment programmes will be detailed in this chapter. The impact of mathematics enrichment programmes on the teaching and learning of mathematics is also be discussed along with the supporting theoretical frameworks for mathematics enrichment programmes. Chapter two also presents literature related to affect and emotions in mathematics enrichment programmes and discusses literature related to the Mathematics Enhancement Programme. Areas of discussion include, the programme structure, the roles of Subject Knowledge Enhancement (SKE) and lesson study in preparing teachers to effectively integrate the MEP into their practice, the impact of the MEP on the teaching and learning of mathematics, the impact of the MEP on students' disposition towards mathematics, the barriers associated with integrating the MEP into Mathematics classes and developing culturally sustaining practices through the implementation of the MEP. This chapter will also discuss the gaps identified in the literature. Chapter Three outlines the use of a mixed method research design approach and discusses the method used to collect and analyse data. The results from the intervention are presented in Chapter Four and are analysed in Chapter Five. Chapter Five also draws together the findings and outlines suggested recommendations in light of this research.

CHAPTER 2: THE LITERATURE REVIEW

2.0 INTRODUCTION

This review examines literature related to the integration of the Mathematics Enhancement Programme (MEP) into primary schools in Jamaica. It discusses the need for, and what constitutes, an enrichment programme, and its potential impact on the teaching and learning of mathematics. To fully develop an in-depth understanding of this impact, it is necessary to discuss what happens in traditional mathematics classrooms. The literature review also provides an overview of the supporting theoretical frameworks for mathematics enrichment programmes and discusses affect and emotions in mathematics enrichment programmes. This literature review also examines how mathematics enrichment programmes can be culturally sustaining.

2.1 TRADITIONAL MATHEMATICS CLASSROOM TEACHING

2.1.1 Teaching Mathematics using Traditional Teaching Methods

Traditional teaching methods are teacher-centred instructions that embrace behaviourism (Hackmann 2004; Nesmith 2008). Behaviourist learning theory propounds that learning is a change in behaviour due to students' passive learning experiences (Amit & Fried 2002; Ormord 1995). Within the behaviourist learning environment learners tend to develop automated responses to given problems (Montilla, 2019). Behaviourism in mathematics education is based on drills and practices that focus on procedures and outcomes arranged hierarchically (Klinger, 2011). Hackmann (2004) asserts that a mathematics classroom that uses traditional teaching methods is representative of behaviourist theory, since the teacher's role in this context is to review previous material and homework, and then demonstrate low-level problem-solving followed by seatwork involving a primary focus on the teacher as the transmitter of knowledge (teaching by telling).

Traditionally, mathematics classrooms require students to listen quietly as teachers lecture about the proper way to complete math problems (Bono, 2002). Klinger (2011) suggested that within the traditional mathematics classroom, mathematical knowledge is external, absolute, and learning is didactic. The role of students in traditional mathematics classrooms is to practice skills and procedures repeatedly until a minimum level of competence is attained (Grady, Watkins and Montalvo, 2012). The preceding views were endorsed by Tuleram and Machisella (2018, p.129) who posit that, 'Traditional teaching approaches are generally teacher-directed, where students are taught in a manner that is conducive to sitting and listening'. Bishara (2018) added that the traditional approach to learning treats the group of learners as homogeneous where the teacher instructs everyone uniformly, with no regard to the differences between them. Also, learning within traditional mathematics classrooms is seen as the correct application of appropriate algorithms to obtain correct answers by studying worked examples (Klinger, 2011, p. 11). Ardeleanu (2019, p.134) paints a vivid picture of the expected setting of a classroom where traditional methods are used as:

> …students are usually seated, allowing everyone to have a clear view of the teacher in front of the class…the teacher has the lead role. He/ she teaches a new concept, ensuring that it relates the new concept to the concepts previously learned by the students. The teacher usually uses a black or white board to work on a short set of examples and to explain the concept… students work individually on solving problems, while the teacher walks around the class and provides additional explanations where necessary.

Skinner (1971) identified rote memorizations, drills and recitations as the foundational basis for traditional teaching methods. Within traditional mathematics classrooms the teacher's role is to 'provide clear, step-by-step demonstrations of each procedure, restate steps in response to student questions, provide adequate opportunities for students to practice the procedures, and offer specific corrective support when necessary' (Smith, 1996, pp. 390-391). Also, traditional mathematics instructions are based on the transmission or absorption view of teaching and learning (Clement and Battista, 2009, p.6). Teaching mathematics using traditional methods occurs when students are passively guided, by a teacher, through a curriculum of established mathematical concepts (Ardeleanu, 2019 p. 134). Grady, Watkins and Montalvo (2012, p.37) added that 'the traditional approach to mathematics instructions is synonymous to the procedural-formalist curriculum which emphasizes a set of logically organized facts, skills and procedures that are perfected overtime'.

Clement and Battista (2009) purport that within traditional mathematics classrooms students are passive absorbers of the mathematical structures invented by others and recorded in texts or known by authoritative adults. Innabi and Emanuelsson (2020) added that, traditional mathematics learning is a combination of memorizing a series of facts and mastering procedural manipulations. Within this context, students are told procedures for solving given mathematical problems, required to memorize that procedure, and subsequently use that memorized procedure to solve similar problem types (Tobias, 2020, p. 170). Traditional mathematical procedures only serve the purpose of enabling students to practice their computational skills within the given context (Jurdak, 2016, cited in Bourne *et al*., 2017, pp. 28-29). Bourne *et al*. (2017) surmised that this approach only facilitates the practice of algorithmic problem-solving and negates the issue of conceptual understanding.

2.1.2 The Impact of Traditional Teaching Methods on the Teaching and Learning of Mathematics: Why is Transitioning Necessary?

The traditional mathematics classroom mainly supports students in the acquisition of academic knowledge and skills rather than in developing key competencies (EU 2002; Eurydice 2010). Acquisition of knowledge in these classrooms is based on rote learning and practice methods (Montilla, 2019). The practice of memorizing facts is aimed at helping students develop automaticity and proficiency in the skills being taught (Bono, 2002). It has been suggested that traditional mathematics instruction has been unsuccessful in promoting the development of conceptual understanding and in supporting the real-life applicability of mathematics (Alsup and Sprigler, 2003). Studies have shown that within the traditional mathematics classroom, the use of illustrative methods to teach is typically minimal; a practice which has proven to challenge weaker pupils and makes it difficult for them to understand the material regardless of the efforts they put forth (Israeli, 2008; Nottingham and Verscheure, 2010). Only those students capable of absorbing, accumulating, and regurgitating information in this manner excel in traditional mathematics classrooms (Battista 1994; Brandy 1999; Hiebert 2003) cited in Nesmith (2008).

The traditional mathematics classroom, which is teacher-centred and enforces behaviourism (Hackmann, 2004; Nesmith, 2008), has been found ineffective in promoting conceptual understanding (Alsup and Sprigler 2003) as its framework is primarily built on drills, rote memorization, and recitations (Skinner, 1971). Satchwell and Loepp (2002) argue that students learn much better when they are encouraged to discover their own knowledge; a practice that is not encouraged in traditional mathematics classrooms. This view was endorsed by Tobias (2020) who asserts that a more student-centred classroom allows the teacher to have greater insight into how students are thinking. This allows educators the opportunity to have a better understanding of how students think differently, which will enable the tailoring of instructions to meet their needs. Phillips and Soltis (2009) suggest that teachers should not ignore the role played by pupils' own experiences and should be aware that students experiences are not merely amassing concepts and operations but involve organizing these internally in some way. As pupils develop their own understanding based on the relationship between prior knowledge, existing ideas, and new experiences, they must be encouraged ‘to wrestle with new ideas, to work at fitting them into existing networks, and to challenge their own ideas and those of others’ (Van De Walle 2007, p. 23) to subsequently enlarge the framework from which new ideas may be formulated (Battista 1994; Van De Walle 2007). As previously suggested, it is considered important that learners actively explore mathematical concepts to build the necessary structure of understanding (Satchwell, 2002; Tobias, 2020 and Van De Walle, 2007). Considering this, the teaching of mathematics can be reconceived as the provision of meaningful problems designed to encourage and facilitate the constructive process (Schifter and Fosnot, 1993, p. 9).

Pupils’ perception of mathematics and their experiences of mathematics can influence their success, self-esteem, and self-confidence with the subject (Pietilä 2002, cited in (Myllyntausta 2012, p. 26). Furthermore, Bishara (2018) is of the belief that teaching methods are closely correlated with pupils’ self-image and the motivation to learn. Pupils with a positive self-image and who believe in their ability, are more likely to advance in learning math despite their difficulties. Motivation to learn is a process that awakens and propels pupils to achieve a goal and to behave appropriately and pragmatically (Mimon 2008; Pintrich and de Groot, 1990). It is based on this premise that it was deduced that, ‘A mathematics classroom should be such that it uses teaching methods and an array of social structures to allow for and develop all types of learning experiences’ (Kashti, Arieli, and Shlansky, 1997). The teaching of mathematics therefore requires the development of a positive atmosphere that offers different kinds of experiences in mathematics, to help pupils to develop a positive disposition towards the subject (Myllyntausta 2012, p. 26).

Positive engagement and experiences of autonomy and competences cannot be enhanced by the task design alone, as it mainly depends on the teacher’s facilitation in the classroom (Schnell and Prediger, 2016, p.152). Teachers' classroom facilitations through discussions, discovery learning, concept development tasks and problem-based learning are considered crucial for teaching mathematical depth and for connecting main ideas (Swan, 2008). One way in which educators can achieve this form of facilitation is through the development and implementation of mathematics enrichment programmes. Piggott and Black (2011) suggested that good mathematics education should incorporate a teaching approach that reflects a constructivist view of learning and stresses non-assertive mediation, group work, discussions, and communication. Studies have shown that mathematics enrichment programmes have played a pivotal role in helping teachers to engage students in rich activities that will aid in unlocking hidden mathematical potentials, building students conceptual understanding of mathematical ideas, developing students' critical and problem-solving skills and subsequently helping students to attain success in mathematics (Fiddyment, 2014; Piggott 2011a; Schnell and Prediger, 2016). Pope (2010) is of the belief that rich tasks also help to develop students' process skills in mathematics.

> A rich mathematical task should engage everyone's interest from the start…;allows further challenges and is extendable; invites learners to make decisions about how to tackle the activity and what mathematics to use; involves learners in speculating, hypothesis making and testing, proving, or explaining, reflecting and interpreting; promotes discussion and communication; encourages originality and invention; may contain an element of surprise; is enjoyable allows learners to develop new mathematical understandings. (Pope, 2010, p. 6)

Therefore, it is clear that the evidence provided in the literature suggests that there is a need to transition from traditional mathematics classrooms to enriched mathematics classrooms.

2.2 MATHEMATICAL ENRICHMENT PROGRAMMES

2.2.1 What is Enrichment?

Enrichment as defined by Clendening and Davies (1983) is any learning experience that replaces, supplements, or extends instruction beyond the restrictive boundaries of course content, textbook and classroom, and that includes depth of understanding, breadth of understanding and relevance to the student and to the world in which he or she lives (cited in Wiggins, Harding and Engelbrecht 2017). The views of Clendening and Davies (1983) are supported by Fiddyment (2014) who posits that enrichment programmes can provide exploratory activities, in-depth materials on a topic, materials for the development of higher-level thinking processes and skills, self-selected independent projects, or authentic products or services for a real-world audience. (Schnell and Prediger 2016, p. 149). Enrichment simply means, ‘to expand students’ experiences and skills by exposing them to rich learning processes’ (Schnell and Prediger, 2016, page 149). Taylor (2019) added that enrichment encourages students to take a more expansive and in-depth look at a concept or topic, perhaps by further research, approaching it with a different lens or perspective, or connecting the subject to a more meaningful or rewarding facet of the real world.

Piggott (2011a) repositioned enrichment in a mathematical context as an open and flexible approach to teaching mathematics which encourages experimentation and communication. As put forward by Schnell and Prediger (2016), enrichment has been realized by broadening where additional mathematical topics or subjects are learnt or enriched by deepening where the depth and complexity of the treated aspects and practices are enhanced.

> Enrichment is the enhancement of mathematical experiences and may feature: the study of mathematics beyond the standard curriculum as defined by the requirements of any external examinations; alternative and creative approaches to topics, including open-ended investigations; accessible aspects of mathematics lying outside the curriculum; connections between aspects of mathematics usually met separately; the mathematics of other subjects or found

> in other subjects; the history and development of some of the deepest ideas of mathematics; mathematics of particular relevance to the students, e.g. related to their locale or to the school's specialism; visits out of school by the students or visits to the school by outside speakers.(The Primary ATM/MA and 11-16 MA Sub-Committees, 2012, p. 2)

Piggott (2011a) further suggests that an enrichment curriculum is aimed at supporting a problem-solving approach to learning, improving pupil attitudes, developing a growing appreciation of mathematics as a discipline and developing the conceptual structures that support mathematical understanding and thinking.

2.2.2 The Mathematics Enrichment Curriculum

As suggested by Raja and Mythily (2018), an enrichment curriculum is essential to the teaching and learning discourse as it adds greater value to the existing content, and it adds life to the overall education process. It was however recommended that the enrichment curriculum should not be viewed in isolation or in a vacuum without the involvement of classroom teachers. An enrichment curriculum should consist of content with engaging problems which develop and use problem-solving strategies and encourage mathematical thinking; the content opportunities provided in an enrichment curriculum should be designed to include historical cultural contexts and offer opportunities for mathematical extensions (Pigott, 2011a; Piggott 2011b).

> The aim of an enrichment curriculum is to support: problem-solving approach (either through, about or for problem-solving) that encompasses the four element model, improving pupil attitudes, a growing appreciation of mathematics as a discipline, the development of conceptual structures that support mathematical understanding and thinking. (Piggott, 2011a, p. 1)

To effectively implement an enrichment curriculum, Piggott (2007, pp.38-39) suggested that teachers will need to identify resources and contexts that support the needs of the learners and the ordered development of skills by utilising, for example, gradients of similarity and complexity. Teachers also need to create an atmosphere in which they engage in dialogue and other interactions including the use of modelling and metacognition and the use of props or cues, as teaching and learning tools. Their aim is to create a community where learners are involved in developing appropriate language that enhances the communication as a vehicle for sharing ideas and individual and communal sense making. The individual learner is valued within the group by encouraging them to be creative, independent thinkers who have time to explore starting points and alternative routes. Different approaches are valued but learners also engage in a critical evaluation of effective and efficient methods.

2.2.3 The Mathematics Enrichment Curriculum and Constructivism

Ernest (2000) suggested that enrichment curricula should aim to support the development of conceptual structures. ‘Constructivism is defined as a dynamic and interactive conception of learning in which all knowledge is constructed; it is a product of the cognitive acts of the individual’ (Glaserfeld, 1989, cited in Greenes, 2008, p. 56; Piaget, 1970; 1980). As outlined by Greenes (2008, p. 56) ‘learning occurs when children's conceptions are challenged by more complex situations, different contexts, or by conflicting data or information’. It has been surmised that constructivism has its foundation built on two principles. These principles are ‘knowledge is not passively received but actively build up by the cognizing subject and the function of the cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality’ (Glaserfeld, 1989, p. 162 cited in Grady, Watkins and Montalvo, 2012, p. 38). Piggott (2011b) recommended that the teaching approach enforced by a mathematics enrichment curriculum should reflect the constructivist view of learning. The teaching approach enforced by mathematics enrichment programmes should also stress the incorporation of group work, discussions, explorations, making mathematical connections, extending boundaries and flexibility. Additionally, Smart (2011) suggested that the lessons developed and taught in an enrichment programme should demonstrate the constructive nature of mathematics. Van de Walle and Folk (2007, p. 34) cited in Smart (2011, p. 239) found six features that contributed to constructivist teaching methods of mathematics; These features are

> a) children construct their own knowledge and understanding; we cannot transmit ideas to passive learners, b) knowledge and understanding are unique for each learner, c) reflective thinking is the single most important ingredient for effective learning, d) the socio-cultural environment of a mathematical community of learners interacts with and enhances students' development of mathematics ideas, e) models for mathematical ideas help students explore and talk about mathematical ideas, and f) effective teaching is a student-centered activity (Van de Walle & Folk, 2007, p. 34, cited in Smart, 2011, p. 239)

The constructivist approach to mathematics instructions views learning as an active process (Grady, Watkins and Montalvo, 2012, p. 38). There are two basic tenets of constructivism. The first tenet suggests that 'Knowledge is actively created or invented by the child, not passively received from the environment. This idea can be illustrated by the Piagetian position that mathematical ideas are made by children, not found by a pebble, or accepted from others like a gift' (Sinclair, in Steffe and Cobb, 1988, cited in Clements and Battista, 2009, p. 6). Secondly, 'Children create new mathematical knowledge by reflecting on their physical and mental actions. Ideas are constructed or made meaningful when children integrate them into their existing structures of knowledge' (Clements and Battista, 2009, p.6). Clements and Battista (2009) further suggest that constructivist instructions give preeminent value to the development of students' personal mathematical ideas. *'In Constructivist instructions students are encouraged to use their own methods for solving problems…and are not asked to adopt someone else's thinking but encouraged to refine their own'* (Clement and Battista, 2009, p. 7).

Students tend to gain a robust and more lasting understanding of concepts when they learn using the process of investigation to explore the big ideas of various concepts (Greenes, 2008, p.55). Evidence provided in educational research indicated that students learn well mathematically when they are afforded the opportunity to construct their own mathematical understanding (MSEB and National Research Council, 1989, cited in Clements and Battista, 2009, p. 6). Briars and Resnick (2000) found that students who are exposed to the constructivist principles showed significant improvement in their mathematical skills, conceptual understanding of mathematical concepts and problem-solving skills. Studies have found that performance in mathematics is positively impacted when mathematics curricula embrace constructivist principles (ARC Center, 2001; Briars and Resnick, 2000; Riordan and Noyce, 2001; Waite, 2000)

2.2.4 The Mathematics Enrichment Curriculum and Problem-Solving

Piggott (2011a) outlines that, a mathematics enrichment curriculum has a particular view of teaching and learning that supports problem-solving. As put forward by Ifamuyiwa and Ajilogba (2012), problem-solving refers to the efforts needed in achieving a goal or finding a solution when no automatic solution is available and that problem-solving could be seen as the ability to use acquired knowledge to find solutions to identified problems by carrying out sets of action. Problem-solving in mathematics is an intricate process which calls for a problem-solver who is engaged in a mathematical task to organize and deal with domain-specific and domain general pieces of knowledge (Yeo, 2009). To substantiate this view, Yeo (2009) cited the work of Mayer (1982;1987) who explained the problem-solving process as using different forms of knowledge applied in problem-solving, which consists of linguistics and factual knowledge about how to encode data, schema knowledge about relations among problem types, algorithmic knowledge about how to present distinct procedures, and strategic knowledge about how to approach problems.

The National Council for Teachers of Mathematics (2000) described problem-solving based teaching as, using interesting and well-selected problems to launch mathematical lessons and engage students. New ideas, techniques and mathematical relationships emerge and become the focus of discussion. Good problems can inspire the exploration of important mathematical ideas, nurture persistence, and reinforce the need to understand and use various strategies, mathematical properties, and relationships (p. 182). Problem-solving involves systematic application of acquired knowledge to overcome any obstacle perceived by an individual as a problem (Ogunyemi, 2010). That is, in order for one to problem-solve he/she must do so using a properly sequenced pattern or steps. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understanding (NCTM, 2000). If students are to be engaged in problem-solving activities, they need to develop a way of thinking consistent with mathematical practices, in which problems or tasks are seen as impasses that need to be examined in terms of questions. Thus, students need to problematize their own learning (Yeo, 2009). Students therefore need to be taught problem-solving strategies in order to develop good problem-solving skills. One way to teach students to problem-solve is to teach the four steps developed by Polya (1971): understand the problem; devise a plan; carry out the plan; and look back (Perveen, 2010). Once students have an in-depth understanding of how to effectively apply problem-solving strategies, students will become better problem-solvers, which will positively impact their performance in Mathematics. This view was endorsed by Chapman (1997) who asserts that experience in solving-problems is very important in helping students to develop their thinking skills and gain more skills in solving other problems in daily life. Additionally, by developing problem-solving skills in mathematics, students should acquire ways of thinking, habit persistence, curiosity and confidence in unfamiliar situations that will serve them well outside the classrooms (NCTM, 2000).

It has been found that problem-solvng is important in mathematics teaching and mathematics programmes which includes enrichment programmes (Howland, 2001; NCTM, 1989; NCTM, 2000). Karatas and Baki (2013) suggest that problem-solving is important as a way of doing, learning and teaching mathematics. It is therefore important to prepare mathematics curricula that promote problem-solving. However, problem-solving should not be an isolated part of the curriculum (NCTM, 2000).

Teachers have an important role in the development of students' problem-solving skills and they should seek to choose problems that engage students (NCTM, 2000). Recent studies have also suggested that there is a need for teacher to implement enrichment activities that augment students' mathematical problem-solving skills. Enrichment in this context is the process of engaging students in activities that will optimize their problem-solving skills (Barmby, Bolden and Thompson, 2014; Lanante, 2019). Barmby, Bolden and Thompson (2014) recommend that teachers seek to develop a broad and rich range of skills in learners that will maximise their opportunity to access problem-solving. Teachers of mathematics should intentionally create and implement concrete enrichment activities that will foster the development of students' problem-solving skills (Lanante, 2019). It was also suggested that problem solving in mathematics can be enriched by integrating discovery learning activities, the use of manipulative and bringing creativity to problem-solving lessons (Barmby, Bolden and Thompson, 2014; Lanante, 2019). Lanante (2009) examined the effect of problem-solving enrichment activities on mathematics achievement and found that when students problem-solving skills are enriched, their performance in mathematics is positively impacted.

Problem-solving is deemed necessary since success in mathematics will be attained when students interpersonal and reasoning skills are developed. One way to develop these skills is through problem-solving (Ifamuyiwa and Ajilogba, 2012). It has been found that enrichment can be used to promote mathematical reasoning and thinking skills (Piggott, 2011b; Piggott and Black, 2011). Studies have also shown that the experience provided by problem-solving through enrichment helps to prepare students to tackle higher mathematics with confidence and a sense of pattern and place (Piggott, 2011b; Piggott and Black 2011). The data from the study of Mullis, *et al*. (2000) showed that pupils' attainment in mathematics is higher when teachers emphasize reasoning and problem-solving.

2.2.5 Benefits of Incorporating Enrichment Programmes in Mathematics Classrooms

Studies have shown that the implementation of enrichment programmes creates an avenue for nurturing social and behavioural skills as well as academic skills (Hynes, O'Connor, and Chung, 1999; Schacter, 2001). This is important as enrichment provides richer and more varied content through modification and supplementation of content in attrition to standard content in the regular classroom (Schiever and Maker, 2003). Additionally, Kim (2016) is of the belief that enrichment programmes have emphasized the importance of profound knowledge and skills within a subject in order to develop students' higher mental processes and creative production. Feng (2010) studied students' experiences of four different mathematics enrichment programmes and found that enrichment helped students to develop greater appreciation for mathematics; a skill necessary for success in mathematics to be achieved. It was also found that enrichment broadened mathematical experiences and horizon and allowed students to see connections within mathematics. Furthermore, enrichment programmes help to keep students enthusiastic and alleviate boredom, and help students discover their true potential and stimulate personal growth (Stanley, 1979, cited in Wiggins, Harding and Engelbrecht, 2017).

Enrichment programmes help improve students' attitudes towards mathematics (Santos and Barmby, 2016) and heighten students' interest in mathematics (Feng, 2006; Feng, 2010). It was found in a study conducted by Santos and Barmby (2016) that mathematics enrichment programmes help students to like mathematics more, enjoy mathematics more and become more confident in mathematics. Another finding of their study indicates that mathematics enrichment programmes help students to feel that their ability in mathematics has improved. That is, after participating in mathematics enrichment programmes students' confidence and sense of capability increased (Feng, 2010). It was also found that mathematics enrichment programmes help students to see the future worth of studying mathematics (Santos and Barmby, 2016).

Enrichment programmes promote higher levels of thinking and creativity in a subject and allow students to explore that subject in depth (Fox, 1979, cited in Kim, 2016). According to Feng (2006) enrichment in mathematics is a way to meet the students' needs for self-activity and to stimulate their interest in the subject further. This view supports the view of Jones and Simons (2000) who are of the belief that enrichment programmes allow students to develop deeper appreciation for mathematics. As suggested by Feng (2006) enrichment in mathematics is positioned to enhance mathematical learning processes as well as develop learning skills. Enrichment in mathematics is also considered to help to deepen students' mathematical understanding (Feng, 2006; Johnson and Sher, 1997). Additionally, it has been found that implementation of enrichment programmes in mathematics positively impacts performance in the discipline (Alzoubi, 2014; Wiggins, Harding and Engelbrecht, 2017)

2.2.6 The Need for Enrichment Programmes

Bishara (2018) opines that there is often a need to change the teaching approach based on the level of dissatisfaction with pupils' achievement. It is necessary to use a wide range of illustrative means and customized teaching methods to alleviate pupils' frustration and provide an opportunity for them to advance academically (Bishara, 2005; Geary, 2004). Additionally, teachers at all levels desire classrooms wherein all students may come to recognize, understand, and utilize mathematics in a manner which allows them to face new quantitative scenarios with confidence and respect (Nesmith, 2008). Enriched mathematics classrooms have been reported to be filling these gaps and have been positively impacting academic achievement (Alzoubi, 2014; Kim, 2016; Wiggins, Harding and Engelbrecht, 2017). Enriched programmes such as the Mathematics Enhancement Programme (MEP) in its conception have drawn on effective international practices (Burghes, 2012). The MEP as an enriched mathematical programme has, 'proven to be a successful strategy because of pupils' high attainment in the discipline with a very low standard deviation' (Burghes, 2000, p. 25).

2.3 THE MATHEMATICS ENHANCEMENT PROGRAMME (MEP) AS AN ENRICHMENT PROGRAMME

2.3.1 The MEP and Its Features

> Mathematical knowledge is fundamental to the understanding and development of science and technology as well as being applicable to many areas in the social sciences. It is vitally important for all countries in this highly competitive global economic environment, yet there are continued difficulties in developing a successful education system which supports all pupils to reach their mathematical potential. (Burghes 2012, p. 5)

This view was supported by McAleavy (2012) who posited that a good understanding of mathematics not only enhances learning in science and technology subjects, but it is also a fundamental skill relevant to many aspects of everyone's working and social life. McAleavy (2012) further opines that improved performance in mathematics aids in equipping students with the needed skills to succeed in a global marketplace and recommends that educators start by laying a good math foundation at the primary level. Students from countries which provide a strong mathematical foundation in the primary sector are more capable of being successful at the secondary level (Burghes, 2012, p.5). As set forward by McAleavy (2012) countries strongest in the field of mathematics implement strong mathematical foundations in the primary years and they encourage and enable their pupils to think mathematically and be creative and confident using mathematics. It is based on this premise and the observation of highly effective practices in mathematically high-performing countries such as Hungary, Poland, Czech Republic, Japan, Singapore, Russia and Finland that the Mathematics Enhancement Programme (MEP) was pioneered (Burghes 2000; Burghes 2012).

'The MEP is a friendly and non-confrontational style of learning that encourages classes to engage in pupil-led discussions and to find solutions to math problem. In this context, the teacher orchestrates the activities but does not lead the class in the traditional way' (McAleavy, 2012, p. 1). The MEP is aimed at challenging all abilities with the expectations that attainment will be positively impacted (Hazell, 2012, p. 34). The MEP provides ample opportunity for educators to develop good classroom practices (Hazell, 2012, p. 37). Beston (2012) added that a positive feature of the MEP is that the programme provides resources with the supporting lesson plans and associated practical aids such as number lines, posters and number cards. Hazell (2012) agreed with the views of Beston (2012) when she posited that one of the most positive aspects of the MEP is the supporting materials that the programme provides, the detailed lesson plans and resources for interactive white board. Beston (2012) suggested that once the MEP is being implemented, educators should use materials suitable for achievement and observe lessons regularly to ensure that they are working at the appropriate level of the children.

The MEP is focused on enhancing primary mathematics based on the hypothesis that the only real way to produce young people who are mathematically confident and capable is to start in the primary phase (Burghes 2012, p. 5). McAleavy (2012) is however of the opinion that enhancing teaching and learning in the primary years requires a change of hearts and minds about what constitutes good mathematics teaching and learning. Beston (2012) affirmed that the MEP has different levels of support needed to facilitate the change process. As put forward by Hazell (2012), the MEP supports children to raise their attainment and progress and provides them with opportunities to explore their own and each another's thinking. The MEP also places emphasis on the development of mental strategies to solve problems (Hunter, 2012a, p. 76). It is excellent at introducing and revising key mathematical vocabulary and mathematical talk within lesson which facilitate pupil attainment (Hazell, 2012, p. 37). It also places great emphasis on language and communication, which involves children working collaboratively and communicating their explanatory reasoning (Hunter, 2012a, p. 76). As put forward by Kellett (2012) the MEP places emphasis on the accurate use of mathematical terms from an early age with the expectations that children are encouraged to come forward and verbally contribute to sessions through consistently explaining their answers to the class. The MEP aids in equipping children with the dispositions to become good learners inspiring them as mathematicians, questioning and challenging them to be logical thinkers and creating a safe environment where they can be confident to excel (Kellett, 2012, pg. 69). Hazell (2012) however concludes that using the opportunities that MEP offers requires learning both on the part of the teachers and the pupils.

As proposed by Burghes (2012), for the MEP to be effectively implemented some key points should be implemented. Table 2.1 outlines the key points of The Mathematics Enhancement Programme (MEP)

Key Points
Lesson – well prepared (teacher knows the lesson plan well and is aware of any problems/ difficulties which might occur), resources are at hand, board prepared in advance, pupils have own resources on desk.
Seating – every pupil has direct eye contact with the teacher and can get to the board quickly and easily. Able children seated beside less able.
Whole-class interactive teaching predominates, with planned intervals of individual and paired work. All pupils on task and all given the chance to demonstrate, answer, explain, suggest, criticise, etc.
Friendly, non-confrontational atmosphere where pupils learn from and support others and have fun! Mistakes used as teaching points. Encouragement given to pupils who have difficulty and praise given when deserved. Pupils are encouraged to appreciate the good work of others.
Spiral curriculum with continual revision; learning by heart encouraged with progression in small, logical steps.
Visualisation and manipulatives are used in the early years and with less able pupils. Contexts are related to pupils' experiences where possible. Demonstrating on a number line and modelling are used to help understanding
Exercises reviewed interactively with the whole class at the same time. Pupils give the solutions, not the teacher, and rest of the class agrees/disagrees or suggests alternative solutions. Pupils are expected to correct their own work (i.e. cross out wrong answer and write correct answer in red). Teacher gives hints only if the whole class is stuck.
Challenges or extension work set for able pupils, or they help their less able neighbours; no one is inactive.
Correct notation, layout and language used at all times. Teacher acts as a model for pupils to follow (on board and orally), repeating/showing a pupil's explanation more clearly and succinctly where necessary. New words always explained and written on the board for pupils to copy in exercise books.
Fast paced and varied activities related to the concept being taught. Time limits set for individual/paired work. Time allowed for pupils to explain and for whole-class discussion.

Table 2.1 The Key Points of the Mathematics Enhancement Programme (MEP) (adapted from 'Enhancing Primary Mathematics Teaching and Learning' (Burghes, 2012, p. 10))

The innovative structure for the MEP ensures that pre-prepared lesson plans and resources support varied, fast paced class work. Also, the spiral curriculum enforced by the MEP is a comprehensive programme that ensures continued revision through small and logical steps but with key aims of mastering each year. That is, rather than simply reviewing the same material until all pupils have it memorized, the spiral process allows for continual development to challenge the most able learners, while also continuing to visit earlier areas of knowledge for those who struggle with math (McAleavy, 2012, pp.1-2). Additionally, the MEP recommends the use of a daily numeracy lesson (45 minutes for Years 1 and 2, 60 minutes for Years 3, 4, 5 and 6)… that emphasis on mental skills and that the lesson structure consists of oral and mental starters, main activities (often with differentiated group work) and plenary session to review progress (Burghes, 2012, p. 7).

> Furthermore, the MEP emphasizes a strong mathematical foundation where its recommended teaching style puts the teacher as the focus of the learning; encourages correct, precise, orderly spoken, and written mathematics; places greater emphasis on whole-class, interactive teaching with less differentiation and less individual work; and promotes mental mathematics, including knowledge of basic addition and multiplication facts. (Burghes, 2012, p. 8)

Smith (2012) identified a list of teaching strategies that teachers may employ to engage learners in MEP lessons. These strategies include taking the time to establish rules, routines, expectations of listening etc; planning ahead… giving children active/concrete experiences prior to the lesson; Modelling; using physical activities, songs, and action games as brain breaks; the use of exercise books for open-ended activities to extend/consolidate learning; getting less confident children out to the front early in the lesson and giving them praise; and changing places/partnerships – particularly if children are anxious or not engaged.

2.3.2 Lesson Study and Its Impact on the MEP

Robinson (2012) contributed to the study on 'Enhancing Primary Mathematics Teaching and Learning' when he addressed issues related to moving forward with lesson study after the implementation of the MEP in the UK. It was argued that lessons should be interesting, thought-provoking, enjoyable, and wherever possible, contain a 'wow' factor that both pupils and teachers take with them as they leave the lesson. For these expectations of a lesson to be achieved, 'A clear definition of quality teaching needs to be established alongside professional development which provides teachers with the capacity and knowledge to consistently deliver great instructions' (Robinson, 2012, p. 39). Guskey (2000) surmised that effective professional development should be an ongoing and embedded process within the teaching profession. Fernandez and Yoshida (2004), cited in Hunter (2012b) outlined that lesson study, developed in Japan, is one form of professional development which aims to increase teachers' knowledge about mathematics, knowledge about ways of teaching mathematics, and knowledge about the ways in which learners engage with and make sense of mathematics. 'Lesson study is one of the major forms of professional development for primary and secondary schools and it is primarily aimed at continually improving the teaching within schools so that pupils learn more' Robinson (2012, p. 40). Burghes (2012) encourages the use of lesson study as the main form of continued professional development (CPD) employed when implementing the MEP because of the benefits it provides to teaching. In rationalizing this stance, Burghes (2012) argued that it is important to facilitate teachers to reflect on their own practice and how it can be improved. It was also suggested that lesson study is essential in equipping teachers with the requisite skill sets needed to effectively implement the MEP.

'Lesson study may be defined as a scientific activity for teachers who try to develop their theories for developing and sharing good practices' (Isoda, 2010, p. 17). This view was endorsed by Robinson (2012) who surmised that lesson study is a vehicle that can be used for sharing good pedagogical practices. Baba (2007) added that lesson study refers to a process in which teachers progressively strive to improve their teaching methods by working with other teachers to examine and critique one another's teaching techniques. Myers (2012) defines lesson study as the process by which teachers work together to determine what is important for students to understand about the content of a lesson and to figure out how to teach the best for their students. Having knowledge of students' learning needs and planning to effectively meet these needs is important to the designing of teaching instruments and the learning process (Misnasanti, Dien and Azizah, 2018, p. 1). Additionally, lesson study is situated within the model of 'learning from practice' and an underpinning belief that teachers can learn and improve their own practice by observing others teach (Isoda, 2007 and Lewis, 2002, cited in Robinson, 2012, p.40). Studies have indicated that lesson study involves teachers working collaboratively to conduct 'study-plan-do-reflect' inquiry cycles designed to improve classroom instructions (Hunter 2012b; Hunter and Back (2011); Lewis and Hurd, 2011; Takahashi, 2014; Wang-Iverson and Yoshida, 2005). Lewis and Perry (2013, p.2) gave a detailed overview of the steps involved in the 'study-plan-do-reflect' process as indicated below:

> Teachers begin the cycle by studying curriculum content and considering their long-term goals for students. Next, they plan a research lesson to be taught by one team member while other team members collect data on student learning. The research lesson provides an opportunity to enact and investigate the team's hypotheses about high quality teaching and learning. During the post-lesson reflection, teachers present and discuss the data collected during the research lesson in order to draw out implications for teaching and learning of the particular topic as well as more broadly.

Isoda (2010) concluded that lesson study is best understood as a tool that may be used to enhance school-based teaching approaches for the professional development of teaching practices.

Lesson study which is aimed at understanding how pupils think and learn (Robinson 2012, p. 40) places teachers at the center of the professional activity (Misnasanti, Dien and Azizah, 2018, p. 1). As set forth by Misnasanti, Dien and Azizah (2018), the teachers' interest and desire to better understand students' learning based on their own teaching experiences is perfected in this professional activity. Teachers actively and collaboratively study content as they engage in lesson study which enables them to build increasingly coherent knowledge, beliefs and routines (Desimone, 2009, cited in Lewis and Perry, 2013). Typically, teachers come together with a shared question regarding their students' learning, plan a lesson to make student learning more visible, and examine and discuss what they observe (Misnasanti, Dien and Azizah, 2018, p. 2). ‘In planning a lesson, they predict how students are likely to respond to specific questions, problems and exercises. Teachers try to put themselves in the position of a student and imagine what it would be like to experience the material and lesson activity as a novice’ (Misnasanti, Dien and Azizah, 2018, p. 2). Lesson study is however ‘not limited in what each participant learned from the class and post reflective activities’ (Isoda, 2010, p.17). Isoda (2010, p.17) elaborated on this view when it was predicated that:

> Each participant reproduces the class with their own developed theories of practice in each of their contexts. On the personal meaning, their theories are just a kind of pedagogical content knowledge, which is working as their local theory on teaching in each of their practices.

Conclusively, Tall (2008) purports that lesson study should not focus on producing the perfect lesson but should instead involve teachers in working together to plan, test, and reflect on lesson sequences which were specifically designed with the aim of improving learning.

‘Lesson study played an important role in the implementation of the MEP in my school’ (Beston, 2012, p. 32). Within the context of the MEP, ‘lesson study is a professional development process whereby teachers work together in year groups or key stage groups to plan, teach, and observe lessons critically and constructively’ (Beston, 2012, p.32). As suggested by Robinson (2012, p. 41) lesson study for MEP should be an ongoing cooperative research project into how children learn mathematics. As put forward by Burghes and Hunter (2012), lesson study should be aimed at enhancing the teaching and learning of mathematics within the MEP. It was also suggested that the objectives for lesson studies associated with the MEP should be aimed at equipping teachers with the skill sets needed to ‘make mathematics enjoyable to pupils, enable students to articulate and demonstrate their solutions in class, enable pupils to demonstrate confidence to work independently on problems in mathematics and improve pupils’ understanding of the logic and rigour needed for mathematics (Burghes and Hunter, 2012, p.98). Burghes (2012) added that lesson study better enable teachers participating in the MEP to develop their own strategies for teaching. Lesson study should seek to design a series of lessons that will enable pupils to:

> Enjoy doing mathematics …to help students learn to enjoy and sense personal reward in the process of thinking, searching for patterns and solving problems; gain confidence and belief in abilities…to develop students' confidence in their ability to do mathematics and to confront unfamiliar tasks; be willing to take risks and to persevere…to improve students' willingness to attempt unfamiliar problems and to develop perseverance in solving problems without being discouraged by initial setbacks; interact with others to develop new ideas…to encourage students to share ideas and results, compare and evaluate strategies, challenge results, determine the validity of answers and negotiate ideas on which they all can agree. (Robinson, 2012, p. 41)

Lesson study aids in the successful implementation of the MEP (Hazell, 2012, p.38). As put forward by Burghes and Hunter (2012), lesson study is crucial for the sustainability of progress when implementing the MEP. Lesson study aids in improving mathematics (Lewis, 2002) and it influences the quality of teaching (Takahashi, Watanabe and Yoshida, 2006). Additionally, lesson study activities are important to the development of mathematics learning instruments (Misnasanti, Dien and Azizah, 2018, p. 5). Burghes (2012) posits that lesson study enable teachers to develop their own strategies for teaching. In a study conducted by Hazell (2012) it was found that lesson study helped the team implementing the MEP to focus on pupil interaction, content and resources and collectively analyse how lessons could be improved. Hazell, (2012) further added that lesson study provided an excellent opportunity for professional development and was a successful way to observe pupil interaction and their progress across cohorts and phases. Engaging in collaborative planning and observational feedback cycles were both crucial to the initial success of the MEP through developing our mathematical knowledge and knowledge of teaching mathematics (Kellett, 2012, p.63). Observing lessons across a range of age groups provided us with the understanding of how the material could be used to empower children and challenge them to think (Kellett, 2012, p. 63). It has also been found that lesson study aids in improving students' achievement in mathematics (Isoda et. al, 2009, cited in Isoda, 2010 p. 25). Additionally, lesson study is valuable in changing hearts and minds and has played a key role in enhancing mathematics.

Lesson study was identified as a rewarding experience for staff members who participated in the MEP (Beston, 2012, p. 32). Lesson study provides multiple opportunities for teachers to access and modify their knowledge of mathematics and that of their children (Lewis, Perry and Hurd, 2009). Also, recent research in mathematics teaching has identified lesson study as a rich context in which to examine teacher's subject knowledge (Lim 2007; Meyer & Wilkerson, 2011; Tepylo & Moss, 2011). Teachers' subject knowledge for teaching which is important to the teaching and learning of mathematics (Adler *et al.*, 2014; Ball, Thames and Phelps, 2008 and Shulman 1986) may be accessed by the participating teachers during the course of lesson study (Chinnappan and Cheah, 2012). Tall (2008) concluded that lesson study has genuine benefits to the teaching and learning of mathematics and as indicated by the work of Robinson (2012) lesson study is vitally important to mathematics programmes, including the MEP.

2.3.3 Subject Knowledge Enhancement (SKE): Why is it Necessary?

The National College for Teaching and Leadership NCTL (2015) asserts that SKE programmes are aimed at updating a candidate's subject knowledge so that he or she is ready to teach. Content knowledge is necessary but not sufficient for teaching (Krauss, Baumert and Blum, 2008; Baumert *et al* 2010). 'Mere content knowledge is likely to be as useless pedagogically as content free skills' (Shulman 1986, p.8, cited in Ball, Thames and Phelps, 2008, p. 391). Shulman (1986) argued that knowing a subject for teaching requires more than knowing its facts and concepts. This view is supported by Ball, Bass and Hill (2004) who suggested that knowing and using mathematics for teaching entails making sense of methods and solutions different from one's own. The subject knowledge for teaching is the bridge between teacher's subject knowledge and enabling the students to know it (Campton and Stephenson, 2014, p.14). Reynolds (1992) suggested that effective teachers connect what they know to new information and rely on their subject matter knowledge to create good lessons and explanations to their students. Shulman (1987) in his work identified the following as major categories of teacher knowledge (table 2.2):

• General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter
• Knowledge of learners and their characteristics
• Knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures
• Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds
• Content knowledge
• Curriculum knowledge, with particular grasp of the materials and programmes that serve as "tools of the trade" for teachers
• Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding

Table 2.2 Shulman's Major Categories of Teacher Knowledge (adapted from 'Knowledge and teaching: Foundation of the new reform (Shulman, 1987, p. 8; cited in Ball Thames and Phelps, 2008, p. 391)).

Mathematical knowledge for teaching is the mathematical knowledge needed to carry out the work of teaching mathematics (Ball, Thames and Phelps, 2008, p.395). Hill, Ball and Schilling (2004) argued that mathematical ability does not fully account for the knowledge and skills entailed in teaching mathematics. Mathematical knowledge is a way of being and acting (Watson, 2008, p. 1) but mathematical knowledge for teaching is the knowledge needed to perform the recurrent tasks for teaching mathematics to students (Ball, Thames and Phelps, 2008). Rowland et. al (2009) described how teachers may apply their mathematical content knowledge in their teaching using the 'Knowledge Quartet' Framework. The knowledge quartet framework involves the application of foundation knowledge which is the knowledge the teacher brings to teaching; connection knowledge which allows the teacher identifies coherence and knowledge of the sequence of the topics from lesson to lesson and within lesson; transformation knowledge which includes the choices of examples and representations the teacher uses, focusing on the teachers' knowledge in action and contingency knowledge which is how teacher responds to a student's unexpected method or content. Specialized subject knowledge is the 'mathematical knowledge which is detailed in a way that it goes beyond what it needed in everyday life' (Campton and Stephenson, 2014, p. 13). Edwards *et al*. (2015) added that being able to explain why a procedure works, presenting mathematical ideas and finding examples and representations of mathematics exemplifies the subject knowledge that teachers require for teaching.

Subject matter knowledge for teaching is the ways in which subject matter can be presented in order to be comprehensible to others along with an understanding of what makes topics easy or difficult (Shulman, 1987 cited in Edwards et. al, 2015). Deep subject knowledge or understanding mathematics in depth is widely expressed as an important dimension of teachers' subject knowledge for teaching (Davis and Simmt 2006; Krauss, Baumert and Blum, 2008; Ma, 1999). The teacher need not only understand that something is so, but the teacher must also understand why it is so (Shulman 1986, p. 9, cited in Alder 2014 *et al*, p. 134). French (2005) argued that a teachers' ability to prepare effective lessons and to respond perceptively and flexibly to the multitude of difficulties that pupils encounter with mathematics is dependent on their own depth of understanding of the topics involved and their own powers of mathematical thinking as well as their more general pedagogical skills and understanding. Teachers' subject knowledge of the mathematical content covered in the school curriculum should be much deeper than that of their students (Adler *et al.*, 2014, p. 134)

Grossman (1990) cited in Ball, Thames, and Phelps (2008) argued that teachers must also draw upon their knowledge of subject matter to select appropriate topics and their knowledge of students' prior knowledge and conceptions to formulate appropriate and provocative representations of the content to be learnt. As put forward by Ball, Thames and Phelps (2008) teachers must also understand the organizing principles and structures and the rules for establishing what is legitimate to do and say in a field. Teachers' orientation to content influences the ways in which they teach that content (Shulman, 1986, cited in Ball Thames and Phelps, 2008). Adler *et al.* (2014) concluded that teachers' attitude and orientation towards mathematics is key to effective teaching.

SKE Pogrammes aid in improving teachers' subject knowledge, attitude, understanding and confidence (Seabourne 2004-2006, cited in Stevenson, 2008). As put forward by French (2005) subject knowledge which embraces depth of understanding, an ability to think mathematically and subject related pedagogical knowledge, as well as content knowledge at an appropriate level, is vitally important to all who teach mathematics. Ball, Thames and Phelps, 2008, p. 400) endorsed this view when they posited that 'Teaching requires knowledge beyond that being taught to students' and teachers require what they call 'unpacked' mathematical knowledge which they use to teach 'decompressed mathematical knowledge' to learners so that students eventually 'develop fluency with compressed mathematical knowledge'. It is therefore implied that teachers of mathematics must have sound technical mathematical knowledge beyond the scope of the grade level that they are teaching before they can effectively help their students develop an understanding of mathematical concepts in the teaching and learning discourse (Ball, Thames and Phelps, 2008; French 2005). Ball, Thames and Phelps (2008) further postulate that teachers who do not themselves know a subject well are not likely to have the knowledge they need to help students learn this content. At the same time, however, just knowing a subject well may not be sufficient for teaching.

This view was supported by Hill, Ball and Schilling (2004) who outlined that evidence from the educational function literature suggests that teachers' intellectual resources significantly affect students' learning. Additionally, students' achievement is driven by teachers' ability to understand and use subject matter knowledge to carry out the tasks of teaching (Ball, 1990; Shulman, 1986; Wilson, Shulman and Richert 1987). Students found that when teachers' subject knowledge is enhanced, they are better able to develop an awareness of understanding the subject in depth and making connections; the value of collaborative working, enjoyment of engagement in mathematical activity (Stevenson, 2008, p. 106). Studies have shown that there is a positive correlation between subject knowledge, teaching quality and student achievement (Baumert *et al* 2010, Hill, Ball and Schilling, 2004)

In rationalizing the need for implementing the MEP, Burghes (2012) identified that too few primary teachers having adequate mathematical knowledge as one of the reasons for the continued difficulties faced in developing an education system that supports all pupils to reach their mathematical potential. Teachers' mathematical competency (mathematical subject knowledge) is a crucial aspect of success in improving mathematics in schools (Burghes and Hunter, 2012, p. 100). If the mathematical competence of teachers is an issue, then focus needs to be placed on mathematical concepts in a relevant and practical way (Burghes, 2012, p.86); one way to achieve this is through building teachers' subject knowledge. It was implied by Burghes 2012, that teachers' mathematical competencies (subject knowledge for teaching) are important to the effective implementation of the MEP. As outlined by Smith (2012) the collaborative practice enforced by the MEP aids in improving teachers' subject knowledge. As put forward by Adler *et al.* (2014), teachers' subject knowledge of mathematical content covered should be deeper than that of their students. For the implementation of the MEP to be successful, Burghes and Hunter

(2012) suggested that the mathematical competency of teachers need to be optimal. To ensure that teachers are mathematically competent the NCTL (2015) suggested that teachers be trained in a SKE programme as it will help them to become ready to teach, a skill necessary for the effective implementation of the MEP. Conclusively, teachers need wide and deep knowledge if they are to respond well, even though the response may often be to ask further questions, and to point to ways of finding out or exploring further (French, 2005, p.2).

2.3.4 Impact of the MEP on Mathematics Education

Previous studies have shown that implementation of the MEP in mathematics classrooms has positively impacted the teaching and learning of mathematics (Hazell 2012; Smith 2012). As outlined by Pitman (2012), the MEP supports improvement in the teaching of mathematics, development in staff capacity, and strengthening the learning community (Pitman, 2012, p. 49). As outlined by Smith (2012), the MEP contributes to an increased sense of collegiality and aids in improving teachers' professional and subject knowledge and understanding. Hazell (2012, pp. 34-36) conducted a study on implementing the MEP in a primary school in the UK and the findings from her study revealed that:

> The MEP provided a structure along with activities and lesson plan. The implementation of the MEP resulted in the teachers flourishing and really enjoying teaching in the programme. These teachers developed their practice and learned through trial and error that the lesson plans did not need to be followed as a script but, as with any scheme, there was a need for teachers to insert their own style and interpretation of the materials to cater for the learners' needs.

As put forward by Hazell (2012), the MEP provides holistic support for teachers, and it helps to equip them with the requisite skills needed to address the misconceptions identified in the teaching and learning discourse. That is, the MEP allows teachers to be able to plan the lesson in a way that allows misconceptions to be explored and resolved through careful questioning and listening to individual responses.

The MEP helps students to develop and display a positive attitude towards mathematics; after the implementation of the MEP, students viewed the subject as interesting and one which was worth persevering when they are challenged by a task (Hunter, 2012a, p. 82). As indicated by Kellett (2012), the MEP encourages students to become active learners. The MEP helped students to develop a sense of autonomy when engaging in mathematics (Hunter, 2012a, p. 79). After being introduced to the MEP, students perceived themselves as autonomous mathematicians who develop their own strategies and analyse solutions to verify they were correct (Hunter, 2012a, p. 82). The most successful lessons are the ones where the students take some ownership of the lesson (Kellett, 2012, p. 66). Conclusively, the MEP aids in making pupils more engaged and seeing themselves as being successful learners of mathematics (Pitman, 2012, p. 47).

The MEP contributes to the holistic growth of students, and it helps to challenge student's thinking (Kellett, 2012, p.65). It aids in creating classroom environments that empowers children to become critical thinkers (Pitman, 2012, p. 49). Hunter (2012a) asserts that the MEP allows students to identify a wide range of positive outcomes from engaging in the practices of listening to explaining mathematical reasoning (p. 76). This view has been endorsed by Smith (2012) who stated that children's use of reasoning, thinking, and mathematical language is positively impacted by the MEP. Additionally, Smith (2012) indicated that the MEP positively impacted students' development and use of mathematical language and their analytical and logical thinking skills. Based on the research done by Burghes (2000), the MEP succeeded in raising students' understanding of basic concepts (Burghes 2000, p. 9). Studies have also indicated that the MEP positively impacted students' understanding of mathematical concepts and attainment (Binns-Thompson, Hornby and Burghes 2021; Burghes 2000, p, 10; Pitman, 2012; 49, Smith, 2012, p.50).

2.3.5 Barriers to Integrating MEP into Mathematics Classrooms

It was found that there are barriers to integrating the MEP into mathematics classes (Beston, 2012; Burghes, 2012; Hazell, 2012; Pitman, 2012; Smith, 2012). Generally, teachers were resistant to the new approach to teaching mathematics (Smith, 2012, p. 50). Beston (2012) examined the early innovations of the MEP and found that teachers were overly concerned as to how the way of working proposed by the MEP would translate into their current context; the older teaching staff members were somewhat resistant to change and for the younger staff, change was seen as a possible threat (risk) in terms of their career progression as they were uncertain how both local authorities and future employers would view this innovation. Beston (2012) expanded this view when it was suggested that it is a difficult task for teachers to try and change the fundamental way they teach. Pitman (2012) found that, teachers initially viewed the implementation of the MEP as demanding. She added that for teachers, the quick pace proposed by the MEP and the number of activities in each lesson were challenging. This view was supported by the findings of Hazell (2012), whose research found that some teachers found the content of the MEP challenging. Additionally, after the initial implementation of the MEP some disliked the content and the way it was perceived to be taught (Hazell, 2012, p.34). ‘In the first year of implementing the MEP, teachers and pupils found the MEP tough going in terms of content and pace’ (Burghes 2000, p. 9). ‘The initial implementation of MEP proved challenging, and a number of issues arose that needed to be addressed. For example, our Year 1 children lacked the fine motor skills required to write in the small spaces provided in the books; additionally, there was no Nursery curriculum. As such issues arose, solutions needed to be found and changes made to address them' (Pitman 2012, p. 47). The MEP was also found by several teachers to be a new and challenging programme that supported children raising their attainment and progress (Hazell 2012, p. 34).

2.4 SUPPORTING THEORETICAL FRAMEWORKS FOR MATHEMATICS ENRICHMENT PROGRAMMES

Mathematics enrichment programmes such as the MEP embrace a student-centred approach to learning with a focus on constructivism, problem-solving and mastery teaching and learning (Burghes, 2012; Ernest, 2000; Fiddyment, 2014; Hazell, 2012; Hunter 2012a; McAleavy, 2012; Piggott, 2011a). The overarching instructional framework of mathematics enrichment programmes is grounded in the cognitive and constructivist learning theories, of major educational theorists such as Skemp, Vygotsky, and Bruner. Skemp's theory of understanding establishes the role of conceptual structures and critical thinking in building students' mathematical understanding. Vygotsky's theory of cognitive development reveals that supporting children's cognitive development in the Zone of Proximal Development leads to a higher level of reasoning (Mcleod, 2023), which is fundamental to problem-solving. Problem-solving, which is viewed by Hausfather (1996) as essential to creating a process of cognitive, social and emotional interchange, is fundamental to the instructional framework of mathematics enrichment programmes (Howland, 2021; NCTM, 1989; NCTM, 2000; Piggott, 2011a). Bruner's learning theory, which encompasses his cognitive structure learning theory, discovery learning theory and constructivist learning theory, provides a framework that embraces student-centred pedagogical practices (Mcleod, no date; Wen, 2018). The learning for mastery (LFM) theory was developed by Bloom, in an effort to address the limitations of the traditional teacher-centred learning environment (Bloom, 1968).

Skemp's theory of learning is a model that describes intelligence as an activity in which learning is 'a goal-directed change of state of a director system towards states which, for the assumed environment, make possible optimal functioning' (Skemp, 1979, p.89). His theory is based on the argument that learners construct schemata to link what they already know with new learning (Skemp, 1985; Skemp, 1979). Schema-constructing activities can be provided for learners through effective learning and Skemp (1989, p.74) describes three modes of building and testing in these settings as:

> Reality building: from our own encounters with the physical world; from the schema of others; from within by formation of higher order concepts.
> Reality testing: against expectations of events in the physical word; comparison with the schemas of others; comparison with one's own existing knowledge and beliefs.

It is highly recommended by Ernest (2000) that mathematics enrichment curricula provide opportunities for the development of schema, that is, conceptual structures. An advantage of creating these opportunities was previously established by Skemp (1961) who is of the view that the successful building of conceptual knowledge structures increased mathematical performance.

Skemp's theory of understanding categorises students' understanding as instructional and rational (Annisa, Aan andTatang, 2019; Kuncorowati, Mardiyana and Saputro 2017; Maclellan, 2014; Skemp, 1978). Instructional understanding is students' ability to memorize rules without reasoning to correctly solve problems while rational understanding is student's ability to apply the rules with the correct process to solve problems and explain the reasons for answers (Annisa, Aan and Tatang, 2019). Rational reasoning which is identified as the most appropriate category of understanding in understanding a concept (Skemp, 1978) is reinforced in mathematics enrichment programmes (Piggott, 2011a). Relational understanding is fundamental to engaging students in knowledge construction (Bereiter and Scardamalia, 2003, cited in Maclellan,

2014) and has a focus on improving students' mathematical understanding (Napaphun, 2012). Maclellan (2014, p. 77-78) maintained that:

> The embodiment of relational understanding in the mathematics classroom is problem-solving. Mathematical problem-solving involves multiple cognitive processes. Complex as it is for learners to negotiate problem representation, and subsequently to deploy relevant mathematical skills, learners must also monitor and evaluate their progress in executing problem-solving processes and use such knowledge to drive forward their own learning. Clearly if learners are to construct problem representations for themselves, teachers' support of this learning must come from triggering learners to use their own cognitive processing and not from giving 'straightforward' procedural guidance.

This makes it clear that an essential component of the curriculum of mathematics enrichment programmes is providing opportunities to build students' critical thinking and problem-solving skills through cognitive processing (Howland, 2021; NCTM, 1989; NCTM, 2000; Piggott, 2011a)

Vygotsky's socio-cultural theory of cognitive development is built on two main principles of his work: More Knowledgeable Other (MKO) and Zone of Proximal Development (ZPD) (Mcleod, 2023; Siyepu, 2013). The MKO refers to someone who has a better understanding or a higher ability level than the learner with respect to a particular task, process, or concept (Galloway, 2001; Mcleod, 2023). The ZPD, which is the gap between a child's actual level of development or what he or she can do and what he or she cannot do without help (Mcleod, 2023; Siyepu, 2013), is essential to the development of mathematical instructional practices (Siyepu, 2013). The ZPD is also defined as 'the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers' (Vygotsky, 1978, p. 86). Vygotsky (1978) added that there are three categories that learners' thinking and problem-solving fall into: learners' ability to perform independently; perform with assistance; and being unable to perform even with assistance. As declared by Vygotsky, cognitive changes occur within the ZPD and instructions within this zone should be designed to reach a developmental level that is just above the students' current developmental level (Mcleod, 2023). Building students' analytical and problem-solving skills in mathematics classrooms will help students reach that developmental level (Galloway, 2001; Mcleod, 2023). Additionally, when learners are in the ZPD for given tasks, if the appropriate assistance is provided, learners will be afforded the advancement needed to achieve these tasks (Galloway, 2001). 'The potential for cognitive development is optimized within the ZPD or an area of exploration for which a learner is cognitively prepared, but requires assistance through social interaction' (Borchelt, 2007, p.2). Siyepu (2013) is however of the view that in teaching mathematics teachers may use learning activities such as textbooks as physical tools to facilitate the learning process of mathematics. This practice is reinforced in enrichment programmes such as the MEP where all students are furnished with MEP workbooks that contain activities that encourage analytical and critical thinking (Burghes, 2012; Smith, 2012) and that push students to reach the developmental level that is above their current developmental levels.

Vygotsky's sociocultural theory of cognitive development stresses the fundamental role of social interaction in the development of cognition (Vygotsky, 1978). He added that community has an essential role to play in how students frame their understanding of concepts being developed. It is through social interaction with a skilful tutor that students learn and develop understanding of concepts (Vygotsky, 1978). Mcleod (2023) established that Vygotsky's Theory of cognitive development of learners is relevant to instructional concepts such as scaffolding. Scaffolding, as described by McLeod (2023), is an instructional practice that supports pupils' learning in a manner that allows them to move from what they already know to new knowledge and abilities. Scaffolding requires teachers to provide students the opportunity to extend their current skills and knowledge. It dictates that learning experiences must be presented in such a way as to actively challenge existing mental structures and provide frameworks for learning (McLeod, 2023). The socio-cultural theory also stresses that the most advantageous learning environment is one where a dynamic interaction between teachers, learners and tasks provides the opportunity for learners to create their own understanding during interaction with others (Atkinson, Derry, Renkl and Wortham, 2000, cited in Siyepu, 2013. The MEP as an enrichment programme places emphasis on dynamic interaction through its enforced whole-class interactive teaching which predominates lessons (Burghes, 2012).

Berger (2005) examined Vygotsky's theory of concept formation and mathematics education and found that this theory is an appropriate framework needed for students to construct new mathematical concepts. 'This framework has constructs and notions well-suited to an explication of the links between the individual's concept construction and socially sanctioned mathematical knowledge' (Berger, 2005, p. 153). Das (2020) added that the importance of mathematics education emerges from the socio-cultural point of view and that for more effective mathematics discourses, students need to be immersed in realistic mathematics concept development processes. Effective concept construction is weighted heavily on how language is incorporated in the process (Berger, 2005; Das, 2020; McLeod; 2023). The two critical roles that language play in cognitive development are, that it is the main means by which adults transmit information to children, and that it is a powerful tool of intellectual adaptation (Vygotsky, 1962, cited in Mcleod, 2023). As stated by Vygotsky (1986) before a child fully develops understanding of a word, he or she still uses that word to communicate purpose. During mathematical concept development, students use words and sign to refer to a mathematical idea before they fully comprehend that mathematical idea (Berger, 2005). Crucial to concept formation is one's use of words to focus on selecting distinctive features, and analyzing and synthesizing them (Vygotsky, 1986, p.106).

Vygotsky's theory presents the usage of sign as a necessary part of concept formation that provides a link between certain mathematical activities and the formation of concepts (Berger, 2005, p. 156).

> That is, the meaning of a concept (as expressed by words or a mathematical sign) is 'imposed' upon the child and this meaning is not assimilated in a ready-made form. Rather it undergoes substantial development for the child as she uses the word or sign in her communication with more socialized others. Thus, the social world, with its already established definitions (as given in dictionaries or books) of different words, determines the way in which the child's generalizations need to develop. (Berger, 2005, pp. 155-156)

Mathematics enrichment programmes create the opportunity for students to develop their own understanding of mathematical concepts (Feng, 2006; Johnson and Sher, 1997), but the understanding created is dependent upon socially/already established notions of the concepts.

Bruner's theory of learning, which is also referred to as discovery learning is student-centred learning that actively seeks to find knowledge of events experienced (Febrianti and Purwaningrum, 2021). The main premise of Bruner's theory is that people construct knowledge by relating incoming information to previously stored information (Febrianti and Purwaningrum, 2021; Wen, 2018). Bruner is also of the view that connecting similar things and organizing them into meaningful structures is the core of learning (Wen, 2018). The purpose of education is not to impart knowledge, but instead to facilitate a child's thinking and problem-solving which can be transferred to a range of situations (Bruner, 1961, cited in Mcleod, no date). Bruner further argued that the essence of learning is that one connects similar things and organizes them into meaningful structures and learning, which involves the organization and reorganization of cognitive structures (Wen, 2018, p. 234). Cognitive structures are referred to by Bruner are representations that can be divided into enactive (action) representation, iconic (image) representation and symbolic representation (Febrianti and Purwaningrum, 2021; Mcleod, no date, Wen, 2018). Enactive representation involves encoding action-based information and storing it in our memory, iconic representation is where information is stored visually in the form of images, and symbolic representation is where information is stored in the form of a code or symbol, such as language (Mcleod, no date). These three representations do not exist in isolation but instead they coexist in individual cognitive structures, complement each other by together working on cognitive activities (Wen, 2018). Bruner (1961) strongly suggests that education should also develop symbolic thinking in children. The experiences created in MEP classrooms aid in building students' capacity to use mental representations while solving given problems (Burghes, 2012; Hunter 2012a; Kellett, 2012). These experiences also allow students to effectively engage in cognitive activities where previously learnt concepts are applied as students create new knowledge and solve problems (Burghes, 2012; McAleavy, 2012).

The way in which people actively choose, retain, and transform information is identified by Bruner as the most important thing in learning (Febrianti and Purwaningrum, 2021). It was further established by Febrianti and Purwaningrum (2021) that understanding the importance of structure will help students decipher facts that are related or unrelated to the development of knowledge. Furthermore, Bruner's learning theory has guiding theoretical significance and practical value for mathematics teaching (Wen, 2018). Bruner argues that 'mathematics is a science that can be learned through the concepts and structures that already exist in mathematics, from these mathematical concepts and structures it can be searched for the relationships contained in the material' (quoted in, Febrianti and Purwaningrum, 2021, p. 48). Wen (2018) clearly paints a picture of mathematics teaching through the lens of Bruner's theory. That is:

> Mathematics teaching should take students' original development characteristics and state as the starting point, give students appropriate tasks, and fully tap the potentials of students, so that every student can reach the maximum development at the original cognitive level. In classroom teaching, the relationship between teachers and students has changed from "authority-obedience" to "value guidance-active participation". Through this process of

> independent inquiry and joint discovery of knowledge, students acquire a successful experience and realize their sense of self-value. Therefore, teachers should actively create conditions to guide students to change their learning styles. (Wen, 2018, p. 283).

This approach to mathematics teaching, based on Bruner's theory of learning, is embodied in the mathematics enrichment programme curriculum with a focus on nurturing students' skill sets, developing higher mental processes and creating discovery-based experiences (Hynes, O'conner, and Chung, 1999; Kim, 2016; Schacter, 2001).

The theory of mastery learning is based on the belief that all children can learn when provided with conditions that are appropriate for their learning (Guskey and Gates, 1986, p. 73). Bloom's learning for mastery (LFM) theory was developed based on his fundamental belief that most students, perhaps over 90%, can master what they are taught (Bloom, 1968). Bloom's LFM theory was endorsed by Block and Burns (1976, p. 3) who outlined that mastery learning 'asserts that under appropriate instructional conditions, virtually all students can learn well, that is, can 'master', most of what they are taught'. The primary goal for mastery learning is for all or nearly all students to 'master' or become competent in the course material (Winget and Persky, 2022, p. 1115). Mastery learning is also aimed at building students' confidence and motivating them to build on their current skills and to acquire new knowledge (Block and Burn, 1976). Bloom (1968) identified aptitude for kinds of learning (time required by learners to attain mastery of given tasks), quality of instruction, ability to understand instruction (understanding the nature of the task and the procedures to follow), perseverance (the amount of time one is willing to spend in learning) and time allowed for learning as the five variables, essential for promoting mastery learning.

Bloom (1968) firmly believes that the instruction provided has a critical role to play in enabling students to master the concepts being developed. There are many different strategies for mastery learning, however, each strategy must find ways of dealing with individual differences in learners through some means of relating the instruction to the needs and characteristics of the learners (Bloom, 1968). This systemic way of teaching allows students to master basic skills, which in most cases form the prerequisite knowledge for subsequent learning experiences (Block and Burns, 1976). Mastery learning also offers students the skills needed to succeed in a society that is constantly changing while keeping in mind the realities of the classroom environment (Block and Anderson, 1975).

Guskey (1997) identified initial learning, formative assessments, corrective activities, and enrichment activities as the steps involved in mastery learning. Within this hierarchical step framework, the specific learning goals or objectives are firstly established, formative assessments are then developed, the organization of corrective activities and the planning of enrichment activities follow, and finally summative assessments are developed (Guskey, 1997). Mastery learning follows a model propositioned by Bloom where students are regularly tested using formative tests and are required to demonstrate mastery on tests (Pelkola, Rasila and Sangwin 2018). Students are assessed on predetermined standards and not relative to their peers (Guskey, 1997). Where students do not meet the desired level of mastery, further teaching, using corrective activities, and testing is repeated until mastery is obtained (Guskey, 1997; Pelkola, Rasila and Sangwin 2018; Winget and Persky, 2022). When students achieve at the desired level of mastery, they are offered enrichment activities to supplement their understanding of the concepts developed (Winget and Persky, 2022).

Essential to mastery learning is mastery teaching. Boyd and Ash (2018) characterized mastery teaching, as framing learning based on dialogue collaborative exploration and concept-building. NCETM (2014) recommends that mathematics programmes engaged in mastery teaching should provide opportunities for students to develop deep structural knowledge and the ability to make connections. The organization is also of the view that precise questioning during lessons, enable students to develop fluent technical proficiency and think deeply about the underpinning mathematical concepts. NCETM added that mastery teaching in mathematics offers differentiation in the form of support and intervention to individual students and not the topics taught. High attainers are challenged through more demanding questions which deepen their knowledge of the same content and students who have difficulties and misconceptions are supported with rapid intervention (NCETM, 2014). Boyd and Ash (2018, p. 218) paint a vivid picture of mastery teaching in mathematics as the process where,

> …teachers are facilitating collaborative learning supported by visualisation and questioning to provoke in-depth exploration of the anchor problem and relevant key concepts through verbal reasoning. This strategy includes developing a learning environment that embraces struggle and mistakes and within which the teacher models verbal reasoning to slowly explore problems in depth, rather than demonstrating quick neat calculation to reach the 'correct' answer to questions. The teachers see this move, to the class exploring a problem collaboratively, as a shift from their previous more didactic teaching where the teacher gives a clear explanation of the single correct solution to a maths question followed by guided practice.

This process of mastery teaching is reinforced in mathematics enrichment programmes such as the MEP which is a friendly and non-belligerent style of teaching (Burghes, 2012; McAleavy, 2012) that allows for the exploration and remediation of mistakes and misconceptions (Hazell, 2012). The MEP encourages students to verbally explain their reasoning (Hunter, 2012a; Kellett 2012).

The mastery approach to teaching in mathematics is based on the three mastery principles that: make use of mathematical representations that expose the underlying structure of the mathematics; help children to make sense of concepts and achieve fluency through carefully structured questions, exercises and problems that use conceptual and procedural variation to provide 'intelligent practice' which develops conceptual understanding and procedural fluency in parallel; and blend whole class discussion and precise questioning with intelligent practice and, where necessary, individual support (Stripp, 2014, p.1). Aspects of these mastery principles form an essential part of the MEP, which identifies whole class interactive discussions as one of its key features (Burghes, 2012). Also, the problem sets that form the activities in the MEP workbooks are structured to foster the development of in-depth understanding of mathematical while enabling students to achieve mathematical fluency (Beston, 2012; Burghes, 2012; Smith, 2012). As delineated by NCETM (2014) the mathematics mastery approach to learning involves teaching that is underpinned by methodical curriculum design and supported by carefully crafted lessons and resources to foster deep conceptual and procedural knowledge. 'Effective mastery curricula in mathematics are designed in relatively small carefully sequenced steps, which must each be mastered before pupils move to the next stage' (NCETM, 2014, p. 2). It was also highlighted by NCETM (2014) that practice and consolidation play a central role in mastery teaching and that carefully designed variation within this builds fluency and understanding of underlying mathematical concepts.

The use of mastery learning strategies aid in improving learning outcomes (Block and Burns, 1976). From the synthesis of research on the effect of mastery learning executed by Guskey and Gates (1986) it was found that mastery learning strategies have a positive effect on students' retention. Winget and Perskey (2022) found that students who are taught using the mastery learning model perform better than those in non-mastery learning models. Guskey and Gates (1986) found through the analysis of Hutlock's (1976) investigation that students who learned under mastery conditions generally liked the subject they were studying more and were more confident of their abilities in it. The differences between fast and slow learners decreased under mastery learning (Anderson, 1975, 1976, cited in Guskey and Gates, 1986). Overall, mastery learning has positive effects on a broad range of student learning outcomes, including students' achievement, retention of learned materials, involvement in learning activities and student affect (Guskey and Gates, 1986, p.78).

2. 5 AFFECT AND EMOTIONS IN MATHEMATICS ENRICHMENT PROGRAMMES

Teaching and learning as described by Gómez-Chacón (2005) is primarily a communication process based on social interaction. The emotions students exhibit during the process are based on their situated social-historical context (Gómez-Chacón, 2005). The key factors in understanding students' behaviour in mathematics are their elements of affect (Gómez-Chacón, 2000). These elements are emotions (affective states such as joy or anxiety), attitudes (positive or negative predisposition toward an activity), and beliefs (learned perspective toward an object) (Gómez-Chacón, 2000; McLeod, 1992). Affect is a natural function of everyday human activity, including mathematics learning and it is essential for human survival, innovation, and interaction (Chiu *et al.*, 2022, p. 3). Affect is also viewed as 'the state of feelings or emotional reactions during the resolution of a mathematical activity, throughout the whole class session' (Gómez-Chacón 2000, p. 150). Affect is categorized in the two systems: global vs local affect and positive vs negative affect (Goldin, 2000; Gómez-Chacón, 2000; Hannula, 2012). As stated by DeBellis and Goldin (2006), local affect involves the changing of emotional feeling during mathematical problem-solving while global affect includes more stable, long-term constructs, which establish contexts for local affect and which local affect can influence. Gómez-Chacón (2000, p.151) added that global affect is:

> …the result of the routes followed (in the individual) in the local affect, which continually contribute to the construction of general structures of the concept of oneself and of beliefs about mathematics and its learning. The global affect has been explored through complex scenarios. The complex scenarios consider the person in his socio-cultural context and in interaction with others. They take into account the learning of mathematics as an element which contributes to the

> construction of the young person's social identity, contextualising the emotional reactions in the social reality that produces them.

Goldin (2000) identified confidence and interest as examples of positive affect and anxiety and frustration as examples of negative affect. Values and motivation were subsequently added as dimensions of affect by DeBellis and Goldin (2006) and Hannula (2012). DeBellis and Goldin (2006) define values as the deep personal truths or commitments cherished by individuals; values motivate long-term choices and shorter-term priorities. Motivation directs behaviour (goal and choices) and has a distinctive influence on choices, which cannot be exhaustively analysed through cognitive and emotional processes (Hannula, 2012, p. 144). All these constructs place affect in all the processes of mathematics learning (Chiu *et al*., 2022). Essentially, affect plays a pivotal role in mathematics activities (Hannula, 2019; Zan *et al*., 2006) and is essential in solving non-routine mathematical problems (Chiu, 2009).

Emotions are very important in the context of education, as they are closely related to achievement-related activities such as problem-solving in a mathematics classroom (Schukajlow, Rakoczy and Pekrun, 2023, p. 253). Chiu *et al*. (2022) established that students' affect or emotions are highly related to key mathematical teaching events where the opportunities created by instructors are aimed at meeting students' need for heuristic-didactic discourse (meta-level learning). Emotions are learning outcomes or goals of mathematics instructions that are important prerequisites for cognitive outcomes; emotions can mediate effects of teaching on cognitive outcomes (Schukajlow, Rakoczy and Pekrun, 2023) That is, emotions are not a mere result of automatic responses or consequences of physiological impulses but rather are a complex result of learning, of social influences and of interpretation (Gómez-Chacón, 2005). Gómez-Chacón, (2000) outlined six emotional responses (calmness, confidence, cheerfulness, being great, being blocked and frustration) in the affective and cognitive contexts during mathematics learning. At the beginning and midway of solving problems, teachers' affective support is needed for students' calmness and active participation as problem-solvers, claim-makers, and solution- reporters (Empson, 2003, cited in Chiu *et al*. 2022). 'The problem solver must have sufficient motivation and lack of stress and/or anxiety to allow progress towards a solution' (Charles and Lester, 1982, p. 10, cited in Blanco, Barona and Carrasco, 2013).

Schukajlow, Rakoczy and Pekrun (2023) are of the view that emotion and motivation related variables may be used as item-level indicators of attitudes or affect. McLeod (1992) opines that repeated emotional reactions are the origin of attitudes. Attitude as defined by McLeod (1992, p. 581) is the 'affective responses that involve positive or negative feelings of moderate intensity and reasonable stability' (McLeod 1992, p. 581). He also posited that keen attention should be paid to the characteristics of different attitudes. That is, students with negative attitudes may feel anxiously afraid of failure, utterly bored, or absolutely hate mathematics while students with positive attitudes may exhibit feelings of excitement and confidence about mathematics (Hannula, 2012, p. 141). Zan *et al*. (2006) found that attitudes developed and exhibited as based on the two beliefs: attitude related to achievement and affective outcomes such as liking mathematics. Beliefs which are formed from one's social context (culture) and individual experiences play an important role in students' emotional reactions in mathematics situations (McLeod, 1992). The beliefs that most influence motivation and achievement in mathematics are students' perceptions about themselves in relation to mathematics (Kloosterman, 2002; Skaalvik & Skaalvil, 2011, cited in Blanco, Barona and Carrasco, 2013). Mathematics-related beliefs are how students view their own mathematical potentials (Hannula, 2012; McLeod, 1992). Hannula (2012, p. 155) presented 'I am good at maths' as an example of mathematics-related beliefs. The way students think about mathematics influences their feelings and dispositions towards the subject (Blanco, Barona and Carrasco, 2013). 'That is, if students have negative beliefs about mathematics or its teaching, they will tend to show adverse feelings towards related tasks, in particular presenting avoidance behaviour or simple rejection of those tasks' (Blanco, Barona and Carrasco, 2013, p. 339). Students' individual beliefs affect the way they use their knowledge and skills for problem-solving (Michaelides, 2008; Pajares and Kranzler, 1995). The beliefs of students influence their achievement on given tasks and impact their motivation and academic performance (Bandura, 1986, Schunk, 1991, cited in Boyd and Ash, 2018). Studies have shown that mathematics enrichment programmes have been instrumental in helping students develop positive elements of affect towards mathematics (Jones and Simons, 2000; Santos and Barmby, 2016), which subsequently, have positively impacted their attainment in mathematics (Alzoubi, 2014; Kim, 2016; Wiggins, Harding and Engelbrecht, 2017).

2.6 DEVELOPING CULTURALLY SUSTAINING PRACTICES IN JAMAICA THROUGH THE IMPLEMENTATION OF THE MEP

2.6.1 Jamaica's Cultural Context and its Role in Education

Culture has come to be regarded as a preeminent factor in understanding learners and learning (Young 2014, p. 349). Culture as defined by Kapur (2018) is the system of norms and standards that a society develops over the course of many generations which influences the conduct of people living in that society. Kapur (2018) further posits that culture is the complete package of knowledge, beliefs, customs, art, morals, law and any other capabilities and habits acquired by individual as members of that society. Gay (2018) added that culture is multidimensional, complex, interactive, and dynamic, in that it is always evolving while providing stability among a common group of people. Jamaica's cultural practices are derived from its colonial past. Its culture, which is essentially driven by a diasporic aesthetic, consists of a blend of

African, Asian and European cultural components (Hall, 2013b). However, the Euro-African Creole culture is considered to be the dominant Jamaican culture (Nettleford, 1998). Evidence of its dominance is manifested in Jamaica's language, music, religious beliefs, visual and performing arts and other behaviours and practices (Williams, 2022).

Jamaica's culture, which is captured in the nation's motto 'Out of Many One People' is a fusion of many cultures forming the Jamaican identity and reputation (Davis, 2010; Wilson, 2004). Some of Jamaica's culture was introduced and established by the people who came to Jamaica, and some were developed on the Island (Wilson, 2004). 'Jamaica has a very eclectic culture that takes everything from the strong history of a struggling people imbedded (this is the word used in the article) in their mindset and the soft singing guitar playing stars of reggae who sing of them, to the bright colour wearing, patois speaking image of the island and mix it all into a beautiful culture known as Jamaican' (Sonis, 2004, pp. 6-7). Cropper (2021) classifies Jamaica's culture as rich and diverse with countless traditions, rituals and superstitions that have developed over the centuries and helped people maintain a sense of connection to their past. Cropper (2021) added that although the Jamaican culture is always changing to align with modernisation and urbanisation, its unique fabric is unchanged.

Jamaica's official language is English; however, the Jamaican Patois (Jamaican Creole) is broadly spoken among locals (Milwood, 2021). 'Jamaican Patois is a colorful mixture of English, some Spanish, and of course African dialect from the many tribes of Africa who were displaced on the island during slavery. It is a melting pot of all these languages and cultures coming together to create a distinctive style of linguistics that is unique and easily identified wherever it may be heard or spoken' (Milwood, 2021, p.2). The Jamaican creole in its most expressive form is used to pen most of Jamaica's poetry, toasting by dubbing of poetry and reggae music (Sebba, 2014). Reggae and toasting are not only significant in providing a centre of attraction towards creole-based culture, but provide access and models of Jamaican creole through social networks and relatively high media profiles (Sebba, 2014).

Most of Jamaica's cultural practices are reflected in its folk forms. Jamaica's folk forms consist of performing arts, entertainment arts, literary arts, visual arts, and culinary arts (JCDC, 2018; Williams, 2018). The music of Jamaica is identified as the most powerful art form and cultural heritage (Williams, 2018). The foundation of Jamaica's music is built upon the experiences of America's Rhythms and Blues music fused with mento and jazz to form blue-beat. This later developed into ska, then the fusion of all these Jamaican musical forms transformed into rocksteady and Jamaica reggae (Gooden, 2003). Jamaica is internationally known through musical legends like Bob Marley for its reggae music (Cropper, 2021; Davis, 2010; Wilson, 2004). Also, its old school ska through reggae and dancehall and its musical legacy looms large and is popular in many countries (Davis, 2010; Wilson, 2004). Other widely known cultural folk forms are Jamaica's ancient dances such as dinki mini, kumina and bruckins party; Jamaican competitions like quadrille, maypole; Jamaican storytelling and dramatization (JCDC, 2018; Williams, 2018). Jamaicans ensure that these folk forms live on from generation to generation through education and the annual Jamaica Cultural Development Commission (JCDC) competitions (JCDC, 2018). These arts are also echoed in the performances of Jamaica's cultural ambassadors located in every Jamaican resort and other cultural attraction sites.

Religion is a critical part of Jamaica's culture (Davis, 2010; Wilson 2004) that helps to shape the lives of many Jamaicans (Wilson, 2004). The most popular religion practised in Jamaica is Christianity (Wilson, 2004). Many Christians combine their beliefs with West African traditions, such as drumming ceremonies (Wilson, 2004, p.6) while others base their Christian belief in revivalism, pocomania, and Zionism (Cropper, 2021, Wilson, 2004). Cropper (2021) identifies Kumina as a popular

Jamaican religious ceremony that combines Jamaican dances, traditional songs, and rhythmic drumming. Another popular religious practice of Jamaicans is Rastafarianism which today has followers around the world (Wilson, 2004, p.5). As outlined by Wilson (2004), small groups of Jews, Muslims and Hindus live and practice their religions in Jamaica.

‘Culture encompasses many things, some of which are more important for teachers to know than others because they have direct implications for teaching and learning’ (Gay, 2002, p. 107). Understanding the practices and norms of cultural groups helps educators to effectively teach and respond to students’ culture within the classroom (Williams, 2022). That is, culture plays a pivotal role in how educational practices are formed and executed. The role of culture in learning moves beyond challenging dominant ideologies or world views; it is about defining and identifying instances, methods and processes of learning that are specific to individuals and groups (Young, 2014, p. 349). As stated by Gay (2000, p.8) ‘culture is at the heart of all we do in the name of education’ because it is important for teachers to identify the role of culture in individuals’ daily life, decision making processes and how they interact with others and their surroundings. This view was expanded by Nettleford (2006), who presented culture in education as the foundation of the curriculum that should influence how we teach. Within this context, mitigating variables that influence the behaviour of the cultural group, provide the criteria for determining how instructional strategies should be modified for students (Gay, 2002; Gay 2018). These cultural tendencies influence the ways children participates in education (Kapur, 2018).

As suggested by Williams (2022), within the postcolonial context, culturally lived and interpreted experiences influence teaching and learning in Jamaica (Williams, 2022). Postcolonialism as defined by Hickling-Hudson, Mathews and Woods (2004) is a process that recognises the philosophical, political, economic and sociocultural consequences of colonialism. Hickling-Hudson, Mathews, and Woods (2004, p.3) further established that the colonial past cannot be neatly separated from the decolonising and postcolonial present or future. Therefore, in framing Jamaica's educational system in its postcolonial perspective, the conflict and paradoxes between decolonisation and colonisation should be examined to help with conceptualizing the cultural traditions and pedagogy experienced in Jamaica (Hickling-Hudson, 2000). It is important to examine the historical foundations of postcolonial societies if we are to understand how what happens in classrooms shape students' attitudes and behaviours towards learning (Evans, 2001, cited in Powell, 2022).

Post-Colonial Jamaica is seeking to strive to squeeze centuries of educational evolutions into decades to free itself from past precedents and the slow progress (Jervier, 1979, p. 16). However, Jamaica's education system is entrenched in the history of the country and layered with many hidden historical events (Stewart, 2013, p. 58). Its current education system is an evolution of the British education system (Stewart, 2013) that consists of a four-tiered education system (Ministry of Education, 2009-2010, p. 1). That is early childhood, primary, secondary, and tertiary education. Formal early childhood education is offered to children ages 3 to 6, primary education lasts for 6 years, students are placed in high schools based on their performance on the primary exit examination and secondary education lasts for 5 to 7 years based on the 11 plus system (Stewart, 2013). Towards the end of 11th grade students take the CSEC examination and those who are successful at this level have the option to attend 6th form and take CAPE or matriculate to tertiary institutions or join the workforce (Powell, 2022; Stewart, 2013). Additionally, Jamaica's Ministry of Education has implemented several reforms and increased budgets to allocate new spaces for students, but the issue of equity is plaguing the educational system (Stewart, 2013). The transformational change needed for Jamaica's education system can be constructed within a critical-inclusive pedagogical approach (Stewart, 2013, p. 65). Nettleford (2006) is however of the view that in postcolonial Jamaica, culture in education is the foundation of curriculum and should influence how we teach.

2.6.2 Culturally Relevant and Responsive Practices' Impact on Mathematics Education

Culturally relevant pedagogy as defined by Ladson-Billing (1995a) is the teaching practice that allows students to maintain their cultural integrity while succeeding academically. In addition to becoming academically successful, culturally relevant pedagogy helps students to cultivate cultural competence by enabling them to accept and affirm their cultural identities and develop critical consciousness (Caldera, 2021). However, Ladson-Billings (1995b) is of the opinion that for students to excel academically, culturally relevant teaching requires teachers to attend to students' academic needs, not merely making students feel good. 'Culturally relevant teaching must meet three criteria: an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of a sociopolitical or critical consciousness (Ladson-Billing,1995a, p. 483)'.

Culturally relevant teachers keep learning as the central focus of the classroom and use the scaffolding instructional practice to promote optimal levels of academic success (Ladson-Billings, 2009). Scaffolding adds to and supports the mathematics learning process by building on students' prior knowledge, which is inclusive of students' cultural knowledge systems, skills, and experiences (Jett, 2013, p. 108). Additionally, culturally relevant teachers possess in-depth understanding of their students as well as the mathematical content knowledge which augment the mathematics learning space (Jett, 2013, p. 109). Ladson-Billings (1995a) examined the pedagogical practices of eight exemplary African American teachers and found that after the implementation of culturally relevant teaching, students demonstrated increased academic ability to read, write, speak, compute, pose and solve problems (p. 475). Ladson-Billings (1995a) also found that students taught using the culturally relevant pedagogical model performed better on given assessments than the students who were not taught with this model. It is therefore necessary for educators to understand culturally relevant pedagogy, and then use that knowledge as a culturally responsive teacher to support students in their classrooms (Dixson and Fasching-Varner, 2009).

Ladson-Billings (1995a) theorized that culturally responsive is the dynamic and synergistic relationship between home/community culture and school culture. Erickson and Mohatt (1982) are of the opinion that culturally responsive teaching (CRT) is the first step for bridging the gap between home and school (cited in Ladson-Billings, 1995a). Culturally responsive teaching (CRT) is defined as teaching that incorporates students' cultural knowledge, cultural practices, prior knowledge and experiences, and performance styles to make learning encounters more meaningful and impactful for them (Gay 2018; Caldera, 2021). Gay (2018, p. 36) posits that CRT is the 'behavioural expressions of knowledge, beliefs, and values that recognize the importance of racial and cultural diversity in learning'. The primary aim of CRT is to represent and validate the cultures of all students (Dixson and Fasching-Varner, 2009; Gay, 2000, 2002; Ladson-Billings, 1995a). Gay (2018) added that CRT should aim to use cultural knowledge to inform learning encounters in the classroom. This would require of teachers to acquire detailed factual information about their students' culture (Gay, 2002).

Learning happens naturally when learners are situated in culture-based context (Young, 2014). Studies have shown that students' academic performance has improved after they were taught through the lens of their culture (Gay, 2000, Gay, 2018; Ladson-

Billings, 1995a, 1995b). Furthermore, understanding learners helps educators to understand human learning across all contexts (Young, 2014). CRT is therefore important to every subject taught in schools (Gay, 2002). For the school subject of mathematics, culture was found to play a significant role in the developing and learning of mathematical concepts (Ernest, 2009; Martin, 2009; Swetz, 2009; Young, 2014), since culture provides the conceptual foundation needed to build content knowledge (Moses, West and Davis, 2009). In support of this view, Hunter and Hunter (2017, p. 2) argued that 'the teaching and learning of mathematics is closely tied to the cultural identity of the learner'. Jett (2013) presents CRT as the pedagogical practices that allow teachers to draw on multiple dimension such as language, art, music and history to augment the mathematics learning process. When teachers connect students' cultural context and values to mathematics lessons, students are afforded the opportunity to accelerate their mathematics and enhance their relationship with mathematics (Hunter and Hunter, 2018). Allowing students to see the connection between math and cultural practices also helps to bridge the decontextualized abstract system often used in teaching mathematics (Lipka and Mohatt, 1998, cited in Gay 2002). Lipka and Mohatt (1998) further argued that establishing this connection, allows students to demystify how mathematics is derived. Additionally, CRT has the potential to support students in retaining their cultural identity while constructing a positive mathematical disposition (Hunter and Hunter, 2017). This connection can be established by enabling the path to learning through the use of learner's native language articulations and personal experiences that translates into written and verbal mathematical concepts (Moses, West and Davis, 2009). That is, the mathematical language, notations and notions should be specific to the culture of the learner (Ng and Rao, 2010). Young (2014) added that using students' native language for the teaching of mathematical content assists in improving mathematics knowledge. Conclusively, CRT positively impacts mathematics education and contributes to students' high achievement in mathematics (Ernest, 2009; Martin, 2009; Ng and Rao, 2010; Young 2014).

2.6.3 Sustaining Jamaica's Cultural Practices through the MEP

Culturally relevant and responsive pedagogies are essential for incorporating students' culture into teaching and learning discourses (Gay, 2000, 2002, 2018; Ladson-Billing 1995a, 1995b). Alim and Paris (2017) present culturally sustaining pedagogy (CSP) as a practice primarily aimed at building on the legacy of culturally relevant and responsive pedagogies. Paris (2021) supports this argument by citing Ladson-Billing (2014, p.76), who is of the opinion that 'Culturally sustaining pedagogy uses culturally relevant pedagogy as the place where the beat drops'. Culturally relevant pedagogy serves as the foundational rhythm that leads the way towards justice, and CSP aligns itself with this approach to education, aiming to prioritize the indigenous community's beauty and future (Paris, 2021). The term 'culturally sustaining' requires that pedagogies be more than responsive to or relevant to the cultural experiences and practices of young people. It requires that they support young people in sustaining the cultural and linguistic competence of their communities while simultaneously offering access to dominant cultural competences (Paris, 2012, p. 95). Culturally sustaining practices seek to promote schooling as a process that sustains different cultural ways of being, teaching students to be resilient and to persevere, and to empower youth to accept and honour their cultural background (Alim and Paris, 2017). Caldera (2021) added that culturally sustaining pedagogy maintains heritage, values, cultural and linguistic pluralism. It has the explicit goal of sustaining and supporting multilingualism and multiculturalism in practice and perspective for students and teachers (Caldera, 2021; Paris, 2012). 'That is, culturally sustaining pedagogy seeks to perpetuate and foster-to sustain-linguistic, literate and cultural pluralism as part of the democratic project of schooling' (Paris, 2012, p. 95).

As suggested by Holleran-Steikeret et al. (2008) when adapting a programme, care must be taken to ground the programme in the targeted population's cultural norms, values, and attitudes (cited in McClowry and Spellman, 2016) as this will aid in developing culturally sustaining practices. It is recommended that the content opportunities designed and embedded in the enrichment curriculum include historical context (Piggott 2011b) to facilitate the development of culturally sustaining practices. Within the Jamaican context, culture guided by government policy and exhibited in the various curricula, is integral to the education system (William 2022, p. 32). William (2022) further argued that the inclusion of Jamaican cultural identity in education is considered an integral part of developing the individual and the collective. Bourne *et al.* (2017) are of the view that if the teaching of mathematics is to be effective in the Jamaican context, it must be taught in a manner that is developmentally appropriate to the learners' cultural background. This suggests that CSP is important to the effective development of math concepts within the Jamaican classrooms.

Currently, there is no empirical literature on how Jamaica's culture can be sustained through the implementation of mathematics enrichment programmes. There are however studies in other disciplines that exemplify the possible ways in which Jamaica's culture may be sustained through the implementation of the MEP. McClowry and Spellmann (2016) examined the cultural relevance of INSIGHTS for Jamaica. In their study, it was established that when adapting a programme, its surface elements should be modified to reflect the social realities of participants' cultural group while maintaining the fidelity of the deep structures of the programme. The adaptation of the MEP models a similar pattern where MEP resources were modified to fit Jamaica's cultural context while maintaining the programme's overarching deep structure (Binns-Thompson, Hornby and Burghes, 2021). In adaptation of evidence-based interventions, like the MEP for a specific cultural group, issues of cultural relevance must be balanced with the fidelity of the core components of the original programme (Castro, Barrera, and Martinez, 2004). This balance is necessary since culture provides its children tools of intellectual adaptation that allow them to use their basic mental functions more effectively (Mcleod, 2023). Vygotsky's theory of cognitive development highlights the significant role of culture in the development of mental abilities such as reasoning (Mcleod, 2023). The MEP places great emphasis on development of mental strategies to solve problems (Burghes, 2012; Hunter 2012a). Within this context, teachers will guide students into challenging their cultural experiences to interpret and respond to problems (McLeod, 2023), thus enabling the MEP to facilitate sustaining students' cultural heritage.

Ruppert *et al.* (2022) studied culturally sustaining practices for mathematics teachers and found that mathematical tools can be culturally sustaining. It was also found that a cultural lens must permeate all math planning as teachers help their students to interrogate their own thinking and ways of knowing. They added that culturally sustaining classrooms should help students develop their own connections to mathematics in their current world and in the world they will one day lead. The mathematical tools introduced by the MEP can be adapted and tailored for new contexts (Binns-Thompson, Hornby and Burghes, 2021), thus enabling students to construct their own connections with the mathematical concepts being developed (Ruppert *et al.*, 2022). This aids in creating a foundation where 'culturally sustaining practices are intentional opportunities teachers engage in and create to support all students' (Ruppert *et al.*, 2022, p. 910). Drawing on the illustrations detailed in this section, there is evidence that the MEP has within its structure opportunities that teachers can utilize to develop culturally sustaining practices in the Jamaican context.

2.7 PRIOR MATHEMATICS EDUCATION RESEARCH AND PROJECTS IN JAMAICA (WHAT ARE THE GAPS IN THE LITERATURE? WHY INTEGRATE THE MEP?)

Very few studies have been done on mathematics education in Jamaica. These studies examined Jamaican students' performance in mathematics, factors that negatively affect attainment in mathematics and how performance in the discipline at the primary level impacts attainment at higher levels (Bourne, 2019; Bourne, 2019; Crossfield and Bourne, 2017; Harris and Bourne, 1997). It was found that the nation struggles with the issue of underperformance in mathematics, that is majority of Jamaican students have not demonstrated mastery of given mathematical courses (Bourne, 2019; Bourne, 2022; Buddo, 2017; Crossfield and Bourne, 2017). Bourne (2022) is of the opinion that there are some fundamental flaws with the competencies of primary-level Jamaican students in mathematics that are crippling the likelihood of them excelling at the secondary level. He presented statistical evidence of a significant decline in Jamaican students' performance at the secondary level when compared to their performance at the primary level. With this trend in performance, Bourne (2022) concluded that it is highly improbable that many Jamaican students will pursue mathematics beyond the secondary level. In a study conducted by Crossfield and Bourne (2017) it was found that teaching practices contribute to students' attainment in mathematics. The pedagogical practices employed in some Jamaican primary mathematics classrooms are not enabling students to develop their conceptual understanding of mathematical concepts (Bourne, 2022). Some Jamaican teachers of mathematics were observed employing traditional teaching methods and teaching for examinations (Bourne, 2019; Bourne, 2019; Harris and Bourne, 1997). Lack of interest and the fear of mathematics were also found as factors that affect attainment in mathematics. Policy makers face diverse challenges concerning how to improve the quality and standard of teaching mathematics in Jamaica (Crossfield and Bourne, 2017, p.2). Bourne (2019) is of the opinion that teachers of mathematics have the responsibility to find creative and innovative ways of teaching.

To address some of the challenges faced in mathematics education the New Horizon for Primary Schools (NHP) was developed and implemented in 72 government schools in Jamaica from 1998 to 2005 (Lockheed *et al.* 2006). This programme was implemented at the primary level because ‘the role of primary education is to lay the foundation for further education and if a good foundation is laid at this level, there is likely to be no problem at the subsequent levels’ (Bourne, 2019, p. 9). The programme provided support to schools based on needs identified through the preparation of school development plans (Lockheed *et al.* 2006). The NHP developed an innovative math programme aimed at training teachers in mathematics and educational technology, providing supplementary math materials and integrating data bases into teaching practices (Lockheed *et al*., 2009, p. 9). During the implementation of the NHP, it was found that primary school mathematics was taught in traditional ways and teachers were tellers who did examples on chalkboards and then had students follow with exercises (Juarez and Associate, Inc, 2004, cited in Buddo, 2015, p. 201). Buddo (2015) detailed that the lessons of the NHP were text-book-oriented and there was no room for students to develop rational understanding of mathematical procedures. The findings from this programme showed that the performance of students in NHP schools was no different from the performance of students in the statistically matched schools on the 2004 and 2005 primary mathematics examinations (Lockheed *et al*., 2006, p. 53).

Buddo (2015) studied teachers’ reflection on the implementation of the Revised Mathematics Curriculum in Jamaica. In 1999, the National Primary Mathematics curriculum was revised to raise the standards of mathematics teaching and students’ performance in the subject. As put forward by Buddo (2015) the revised curriculum placed emphasis on engaging students in the construction of their own knowledge. ‘The curriculum promotes the use of a variety of teaching strategies and activities to develop independent learners, promotes higher-level thinking skills in the students, and facilitates students in noting the integration of mathematics across other curricular areas’ (Buddo, 2015, p. 200). The teachers who participated in this study expressed concerns in using the curriculum document. Some concerns that were shared are:

> lesson planning requires research and group planning; the curriculum guide does not cater to the students who are performing below the grade level; resources stated in the curriculum document are not provided at the school; activities are limited and often unclear; limited resources to execute lessons; need on-going workshop to help teach math effectively…little is offered in the curriculum for the teaching of mathematics; the curriculum suggests more group work and project activities; challenging finding suitable questions. (Buddo, 2015, pp. 207 – 208)

Much of the failure in mathematics among Jamaican schools appears to be due to inappropriate teaching methods (Davis, 2004; William, 2008); teaching methodology is another factor that impacts attainment (Crossfield and Bourne, 2017). Over the years Jamaica’s education system has designed and implemented different interventions and programmes to help with remediating the issue of underperformance in mathematics (Bourne, 2019; Buddo, 2015; Lockheed *et al*., 2006). Major limitations have however been identified with the implementation of these programmes. Such limitations include:

> Minimal to no support systems are in place to help teachers develop and maintain the requisite skill sets needed to effectively implement the programmes. During the implementation of the programmes mathematical concepts are developed using traditional teaching methods. Limited to no support instructional resources are available during the implementation of these programmes. (Buddo, 2015; Lockheed *et al*., 2006)

The MEP has been found to have features that will aid in addressing the limitations identified in mathematics programmes previously implemented in Jamaican schools (Binns-Thompson, Hornby and Burghes 2021). The structure of the MEP allows for the initial and continued development of teachers thus enabling them with the skill sets to effect positive changes in the teaching and learning of mathematics

(Burghes, 2012; Hazell; 2012; Hunter, 2012a; Smith 2012). The MEP fosters the development of these skill sets through the building of teachers' support knowledge through the SKE programme and by offering pedagogical support through mandatory lesson study and professional development sessions (Burghes 2000; Burghes 2012). The MEP also provides workbook and supporting manipulative for students and teachers' support lesson plan resources (Burghes, 2012). It has proven to be a very effective way of developing mathematical concepts in the formative years of students' life (Burghes, 2012). The MEP has, however, never been introduced to Jamaica (or to any other Caribbean Island) prior to the pilot study for this research. There are several documented testimonials outlining its positive impact on performance in mathematics within first world countries. (Burghes 2000; Burghes 2012, Hazell 2012, Smith 2012) but there is no evidence of the impact of this intervention on mathematics education in a third world context.

In 2017, the MEP was adapted, tailored, and piloted in selected primary schools in Jamaica (Binns-Thompson, Hornby and Burghes, 2021). Primary mathematics was targeted since a solid foundation in mathematics is necessary for success in higher levels of mathematics and success in the job market (Bourne, 2019; Burghes, 2012; Mcleavy, 2012). The findings of the pilot study support previous research findings which indicated that the MEP positively impacts the teaching and learning of mathematics (Burghes, 2012; Hazell, 2012; Smith, 2012). It was however noted that no extensive research had been done on the MEP outside of England.

There is very little literature on the MEP because it has not been widely studied. The current literature only addressed the inception and structure of the MEP and the impact of the MEP on mathematics education in the UK (Burghes 2000, Burghes 2012, Hazell; 2012; Hunter 2012a; Kellet; 2012; McAleavy, 2012; Smith 2012). There is no current literature on the global impact of the MEP on mathematics education. Further research of the MEP is necessary to add to the existing body of knowledge. The current literature is lacking evidence of the MEP's impact on mathematics education in third world countries. The exiting body of knowledge would also be enriched if the barriers to integrating the MEP are further studied. Also, studying the strategies for implementing the MEP into mathematics classrooms and the aspects of the MEP teachers view as most beneficial to their practice would add to the existing body of knowledge.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This study aims to investigate the integration of the Primary MEP course into Jamaican Primary Mathematics classes. The type of study that one employs in conducting research is based on the research questions which indicate the nature of data, the number of participants and the research process (Cohen, Manion and Morrison 2007; Drew, Hardman and Hosp, 2008). The research questions for this study require the use of an embedded quasi-experimental research design. Employing the use of an embedded research design afforded an in-depth investigation into the integration of the MEP into Jamaican primary mathematics classes.

Section 3.1 will give a recap of the research questions. Section 3.2 overviews the embedded quasi-experimental research design approach to the study and establishes the justification for using the mixed method research design for this study. Section 3.3 gives a description of the research settings, background, and participants. The research procedure is detailed in section 3.4 and in section 3.5 the ethical considerations concerning collaboration research in a school-based setting such as this one, are established. The data collection procedures are outlined in section 3.6. Section 3.7 describes the data analysis procedures and section 3.8 outlines the reliability and validity of this study.

3.1 RESEARCH QUESTIONS

This research which investigated the integration of the MEP into Jamaican primary mathematics classrooms was guided by the following research questions:

1. How does the implementation of the MEP impact students' performance in mathematics?
2. How does the implementation of the MEP impact students' attitudes and disposition to mathematics education?
3. What teaching strategies are used in implementing the MEP in mathematics classes?
4. What do teachers consider as the most effective teaching strategies for implementing the MEP in mathematics classes?
5. What do teachers consider to be the barriers to incorporating MEP resources and teaching strategies in Jamaican primary classroom?
6. Which aspects of the MEP do teachers think they will adapt and implement in their own practice?

3.2 EMBEDDED QUASI-EXPERIMENTAL RESEARCH DESIGN APPROACH

3.2.0 Introduction

This research is grounded in pragmatism (pragmatic perspective) and draws upon an embedded experimental research paradigm. It has a practical interest in mathematics education, it is contextual and was executed in a naturalistic setting. For a more comprehensive account of the integration of the MEP into Jamaican primary mathematics classrooms it was appropriate to apply an embedded quasi-experimental research design to this study.

3.2.1. Research Paradigm

Morgan (2007) defines a paradigm as a set of shared beliefs that influences the types of knowledge researchers seek to obtain and how they interpret any research evidence they may collect. Guba and Lincoln (2005) identified ontology and epistemology as philosophical assumptions that characterize a person's worldview and constitute any paradigm. This view was supported by Teddlie and Tashakkori (2009, p.84) who defined a paradigm as, 'a worldview, together with the various philosophical assumptions associated with that point of view'. Ontology as described by Mack (2010, p.5) is 'one's view of reality and being', whilst epistemology is the 'view of how one acquires knowledge'. Ontologically the mixed research approach adopts a belief in *fallible realism* (i.e. 'all theories are approximations') where researchers 'recognize the existence and importance of the natural or physical world as well as the emergent social and psychological world' (Johnson and Onwuegbuzie, 2004, p.18). Epistemologically, findings are generated through interaction between researcher and data utilizing a logic of inquiry that includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results) (Johnson & Onwuegbuzie, 2004).

Hall (2013a) identified post positivism, constructivism, transformative and pragmatism as the commonly used worldviews. Of these four worldviews 'the transformative and pragmatism worldviews are seen to be compatible with mixed methods research' (Hall, 2013a, p. 3). Pragmatism has gained considerable support as a stance for mixed methods researchers (Feilzer, 2010; Johnson and Onwuegbuzie, 2004; Morgan, 2007). Pragmatism has been identified in the mixed method literature as the appropriate paradigm for conducting mixed method research (Creswell and Plano Clark, 2011; Johnson and Onwuegbuzie, 2004; Morgan, 2007; Teddie and Tashakkori, 2009).

As proposed by Johnson and Onwuegbuzie (2004) pragmatism that draws upon prior work is considered the appropriate philosophy for mixed methods research (MMR). Also, it is suggested that a pragmatic approach for MMR considers what works best for answering the research questions rather than making a choice between the post positive or constructivist paradigm (Johnson and Onwuegbuzie, 2004; Onwuegbuzie and Johnson, 2006). This is by no means suggesting that MMRs are carried out in a haphazard fashion where 'anything goes' (Denscombe, 2008, p. 274). MMRs seek to thoughtfully adopt and integrate the results of the most appropriate methods to answer research questions (Bryman, 2006; Denscombe, 2008).

Morgan (2007) opined that conducting research based on the pragmatic view would not deny any communication between researchers who pursue research in different ways. It was further posited by Morgan (2007) that a pragmatic approach would encourage researchers who use methods in different paradigms to place an emphasis on shared meanings and pursuing joint action. Pragmatism includes pluralism by which it is not logically contradictory to claim that quantitative and qualitative research are both useful (Onwuegbuzie and Johnson, 2006, p. 54). Additionally, Onwuegbuzie and Johnson (2006) suggested that different perspectives that are complementary enable researchers to fully understand research problems and adequately answer research questions. That is, pragmatism is consistent with the idea of paradigms as shared beliefs among members of a specialty area because methods are chosen to tackle a research problem that can be part of the research agenda of a group of researchers rather than being based only on ontology and epistemology (Brierley, 2017, pp. 17-18).

A pragmatic approach was necessary for investigating the integration of the MEP into Jamaican mathematics classes since it allowed the researcher to apply the most practical approach to address the research questions (Brierley, 2017). As put forward by Teddlie and Tashakkori (2009) pragmatists believe that from an epistemological perspective some stages of research take on an objective approach by not interacting with the subjects, while other stages take on a more subjective approach by interacting with the subjects to construct realities. This belief was mirrored in this research since there were stages of it that were objective, and the integration process was observed. Other stages were subjective where there were interactions with the participants. The subjective stage included feedback, lesson study and professional developmental sessions and interviews.

Employing the use of the pragmatic approach to this study aided in creating the middle position (both methodologically and philosophically) needed to mix quantitative and qualitative methods to adequately answer the research questions. It was necessary for this research to mix the objective (quantitative) and subjective (qualitative) paradigms to gain full insight into the impact of the MEP on students' attitude and performance in mathematics, the process of integrating the MEP into Jamaican mathematics classroom, the teaching methods employed during the integration, the impact of the integration on teachers' pedagogical practices and the barriers to integrating the MEP.

3.2.2 Mixed Methods Design

> Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e. g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (Johnson, Onwuegbuzie and Turner, 2007, p. 123)

Mixed methods research is also viewed as a procedure for collecting, analysing, and 'mixing' both quantitative and qualitative methods in a single study or a series of studies to understand a problem (Creswell 2012; Creswell & Plano Clark, 2011). Creswell (2014) added that Mixed methods research involves the collection of both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. Onwuegbuzie and Turner (2007, quoted in Creswell, 2014, p. 266) outlined a more expanded view of mixed methods design which detailed that:

- The procedures for both qualitative and quantitative data collection and analysis need to be conducted rigorously (e.g., adequate sampling, sources of information, data analysis steps).
- The two forms of data are integrated in the design analysis through merging the data, connecting the data, or embedding the data.
- These procedures are incorporated into a distinct mixed methods design that also includes the timing of the data collection (concurrent or sequential) as well as the emphasis (equal or unequal) for each database.
- These procedures can also be informed by a philosophical worldview or a theory

The concept of mixing methods originated in 1959, when Campbell and Fiske used multiple methods to study the validity of psychological traits (Creswell, 2003). Their work prompted others to begin collecting multiple forms of data, such as observations and interviews (qualitative data) with traditional surveys (Sieber, 1973, cited in Creswell, 2014). As established by Creswell (2014), mixed methods research was developed in the middle of the late 1980s and is viewed valuable for neutralizing the bias and weaknesses of qualitative and quantitative data. Creswell (2014) added that by the 1990s mixed methods turned towards the systematic convergence of quantitative and qualitative databases and the idea of integrating different types of designs emerged. Mixed methods research has gone through several periods of development including the formative stage, the philosophical debates, the procedural developments, and more recently reflective positions (noting controversies and debates) and expansion into different disciplines and into many countries throughout the world (Creswell 2014, p. 266). Over time, MMR designs became popular in social science studies because of its advantages, which include the ability to leverage the strengths of varied methods, provide richer insights into phenomena of interest that cannot be fully understood using only quantitative or qualitative methods, address research questions that call for real-life contextual understanding, multi-level perspectives, and cultural influences (Johnson and Onwuegbuzie, 2004; Johnson, Onwuegbuzie, and Turner, 2007; Morgan, 1998; Venkatesh, Brown and Bala, 2013; Venkatesh, Brown and Sullivan, 2016).

As suggested by Venkatesh, Brown and Bala (2013) the mixed methods research approach is useful when researchers want to get 'a holistic understanding of a phenomenon for which extant research is fragmented, inconclusive, and equivocal' (p.36). The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone (Creswell 2014).

Creswell (2008) suggested that mixed method research design should be employed when:

- Both quantitative and qualitative data together provide a better understanding of the research problem than either type by itself.
- One type of research is not sufficient to address the research problem or answer the research questions
- Pragmatism is required, that is, practicality; multiplicity of viewpoints; biased and unbiased; subjective and objective approaches are involved.
- There is a need to incorporate a qualitative component into an otherwise quantitative study

3.2.2.1 Embedded Design

Embedded design as described by Creswell (2006a) is a mixed method design that involves the collection and analysis of both quantitative and qualitative data within a traditional quantitative or qualitative design. That is, within an embedded design, the researcher may add a qualitative strand within a quantitative design, such as an experiment, or add a quantitative strand within a qualitative design, such as a case study (Creswell 2006a, pp 71-72). Within the embedded design, one set of data provides a supportive, secondary role in a study based primarily on the other data type (Creswell 2003). As suggested by Creswell (2006b), embedded research design is employed when a single data set is not sufficient, there is a need to answer different questions, and each type of question requires different types of data (Creswell 2006a p. 91; Creswell 2006b, p. 67). That is, one data set plays a supplemental role within the overall approach (Creswell 2006b, p. 68). The collection and analysis of the secondary data set may occur before, during and/or after the implementation of the data collection and analysis procedures traditionally associated with the larger design (Creswell and Plano Clark, 2010, pp 91-92). As stated by Creswell (2006a, p. 92), the embedded design may also be implemented when 'the researcher identifies the emergent issues related to the implementation of the primary quantitative or qualitative design, and insight into these issues can be obtained with a secondary data set'. Also, as suggested by Creswell (2006a), the addition of supplemental data aids in improving the larger research design. Clark and Creswell (2011) cemented this line of thought when it was posited that the premise of the embedded research design is that a single set of data is not sufficient, and different types of questions need inquiry through a variety of questions.

The embedded quasi-experiment research design, which occurs when the researcher embeds qualitative data within an experimental trial (Creswell 2006a, Creswell 2006b, Creswell 2014) was employed in this research. Embedded experimental research design because of its strength of drawing on both qualitative and quantitative research and minimizing the limitations of both approaches (Creswell, 2014, p. 266) was chosen for this research. Consistent with Venkatesh, Brown and Bala (2013), prior to the selection of a research design, the appropriateness of an embedded quasi-experimental research design, related to strengths, purpose and relevance to this study was thoroughly considered. After careful consideration a concurrent embedded quasi-experimental research design was employed for this study. The research design of this study aided in helping the researcher to develop an in-depth understanding of the integration of the MEP into Jamaican primary mathematics classes by:

- fostering the development of a better understanding of the need for and the impact of this intervention programme through the collection of both quantitative and qualitative data over time (Creswell, 2014),
- assessing whether the intervention has a significant effect (Creswell, 2006a),
- examining the process of this intervention (Victor, Ross and Axford, 2004, cited Creswell 2006a).

Implementing only a quantitative strand of research for this study would provide a limited account of the integration of the MEP into Jamaican primary mathematics classrooms. The collection of only quantitative data would be limited to addressing the impact of the programme on students' performance and attitude towards mathematics. For an integration of this nature, the researcher deemed it necessary for an understanding of the processes involved in the integration of the MEP into Jamaican classrooms and the impact of the programme on participating teachers' pedagogical practices to be studied supplementarily. It is based on this premise that the qualitative strand of research was embedded within the quasi-experimental research design. Allowing for, not only a more detailed analysis of the process involved with this integration, but also aiding in identifying the teaching strategies that fuelled the effective integration of the MEP and the barriers encountered with the integration. This helped the researcher develop a deeper understanding of students' perception of mathematics before and after the integration of the MEP. A visual representation of the embedded quasi-experimental research design model used for this research is shown in figure 3.1.

Figure 3.1 showed that the embedded quasi-experimental research design model used for this research allowed for data to be collected in three phases and that both quantitative and qualitative data were analysed together after all the data were collected.

In phase one qualitative data in the form of classroom observations were collected prior to the implementation of the MEP programme in order to gain insights into teachers' pedagogical practices prior to the implementation of the programme. In phase two both quantitative and qualitative data were collected concurrently. Pre-tests and pre-children's mathematics attitudinal surveys were administered prior to the intervention. The intervention entailed the integration of the MEP into Jamaican Primary classrooms (see section 3.6.2.3). Following the intervention, the post-tests and post- children's mathematics attitudinal surveys were conducted. During this phase, qualitative data in the form of classroom observations were collected. In the third phase qualitative data were collected from teacher interviews and focus group interviews. Both qualitative and quantitative data were then analysed.

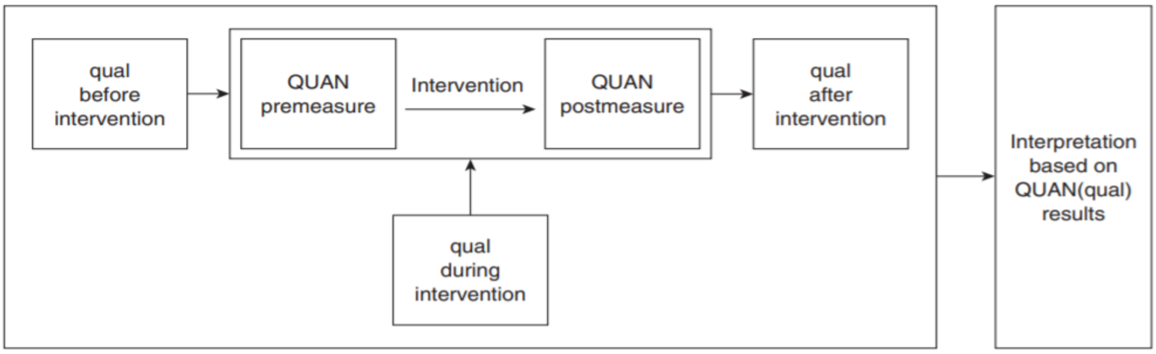


Figure 3.1 Embedded Quasi-Experimental Research Design Model for this Study (adapted from 'Designing and conducting mixed method research: Choosing a mixed method design' (Creswell 2006b, p. 68))

Table 3.1 gives a breakdown of the research questions, the form and type of data collected to address each research question.

Research Question	Type of data collected	How the data was collected
1. How does the implementation of the MEP impact students' performance in mathematics?	Quantitative	Pre- and post- tests
2.How does the implementation of the MEP impact students' attitudes and disposition to mathematics education?	Quantitative and Qualitative	Pre- and post- children's mathematics attitudinal surveys Focus group interviews
3. What teaching strategies are used in implementing the MEP in mathematics classes?	Qualitative	Classroom Observation Teacher interview
4. What do teachers consider as the most effective teaching strategies for implementing the MEP in mathematics classes?	Qualitative	Classroom Observation Teacher interview
5. What do teachers consider to be the barriers to incorporating MEP resources and teaching strategies in Jamaican primary classrooms?	Qualitative	Teacher interview
6. Which aspects of the MEP do teachers think they will adapt and implement in their own practice?	Qualitative	Teacher interview

Table 3.1 Guiding Research Questions, Nature of and how Data was Collected.

3.2.2.2 The Quantitative Design

As outlined by Creswell (2012), when employing a quantitative research design, the researcher decides what to study, asks specific questions, narrows questions, collects quantifiable data from participants; analyses these numbers using statistics, and conducts the inquiry in an unbiased, objective manner. Additionally, quantitative research design, as described by Creswell (2014, p. 32), is '…an approach for testing objective theories by examining the relationship among variables'. Creswell (2014) explained that the variables are in turn measured, typically by instruments, so that numbered data can be analysed using statistical procedures.

It has been suggested that quantitative research design should involve the following key features:

1. Using deductive logic to work from a hypothesis to gathering data to test it.
2. Focusing on many examples that are representative of a population.
3. Following a linear and structured research design with variables and categories set in advance.
4. Gathering quantitative data through instruments such as tests and questionnaires.
5. Using a researcher approach that is detached and objective.
6. Analysing data using descriptive and inferential statistics.
7. Displaying data as graphs, tables, and diagrams.
8. Reporting in a detached, third-person style.
   (Drew, Hardman and Hosp, 2008; Gay, Mills and Airasian, 2009; Mutch, 2005)

It was also detailed that quantitative methodology involves the collection of numerical data that can be analysed statistically (Creswell 2012; Creswell 2014). Such data may be obtained through, pre- and post-test, survey, content analysis and questionnaires. For this research, quantitative data were obtained through children's mathematics attitudinal surveys, and pre- and post-tests.

The two primary quantitative designs are surveys and experiments (Creswell, 2012; Creswell, 2014; Drew, Hardman and Hosp, 2008; Gay, Mills and Airasian, 2009; Mutch, 2005). Fowler (2008) cited in Creswell (2014), stated that survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. A survey is very useful for gathering large-scale data to generalize to a population, and the questionnaire is the most useful tool of the survey when there are a large number of participants (Creswell 2012; Gay, Mills and Airasian 2009, Mutch 2005). As suggested by Creswell (2014) experimental research seeks to determine if a treatment influences an outcome. An experiment compares variables under controlled conditions, and includes two different designs: the true experiment, and the quasi-experiment (Creswell 2014; Gay, Mills and Airasian 2009; Mutch, 2005). 'Experimental research seeks to determine if a specific treatment influences an outcome' (Creswell 2014, p.42). That is, experimental research seeks to test whether the independent variable influences the dependent variable

(Creswell, 2012). An experiment can either be a true experiment with random assignment of subjects to treatment condition or quasi experimental with no random assignment (Creswell 2012, Creswell 2014). For this study, an embedded quasi-experimental research design was employed, and the variables considered are described below.

Independent Variable:

- The MEP

Dependent Variables:

- Students' attainment in mathematics
- Students' attitude towards mathematics
- Teachers' pedagogical practices

3.2.2.3 The Quasi-Experimental Design

Creswell (2014) detailed that in a quasi-experiment, the researcher uses control(comparison) and experimental (intervention) groups but does not randomly assign participants to groups. The pre-test-post-test non-equivalent control group design is a well-recognized form of quasi-experiments and most used in educational research (Creswell, 2012; Creswell 2014: Drew, Hardman and Hosp, 2008). This design is believed to be comparatively rigorous because it involves the pre-test and post-test which are equivalently administered to both groups, and this addresses the weakness that the two groups are not precisely matched. For field settings where matching is impracticable, it is suggested that researchers use samples from the same population or samples that are as alike as possible (Kerlinger, 1979, cited in Creswell, 2014). Robson (1993, p. 46) recommended using the comparison of intact groups (e.g., existing classes in schools) rather than samples selected and allocated for the purposes of the study. Creswell (2014, p. 215) added that 'In many experiments, however, only a convenience sample is possible because the investigator must use naturally formed groups (e.g., a classroom, an organization, a family unit) or volunteers'.

This research employed a pre-test, treatment experiment (integration of the MEP into Jamaican Primary classrooms), post-test using 5 schools (3 experimental and 2 comparison). The five schools were used for comparison and generalizing of results. A pre-post-test design requires that data is collected on study participants' level of performance before the intervention took place (pre-), and the same data on where study participants are after the intervention took place (post). This design is the best way to be sure that the intervention had a causal effect.

3.2.2.4 The Qualitative Strand

The qualitative strand embedded within this traditional quasi-experimental research is a component of the study that encompasses the basic process of conducting qualitative research and the data source plays a supporting role in the overall design (Creswell, 2014). Qualitative research as described by Creswell (2012), is a type of educational research in which the researcher relies on the views of participants, asks broad, general questions, collects data consisting largely of words (or text) from participants, describes and analyses these words for themes, and conducts the inquiry in a subjective, biased manner. Creswell (2014, p. 32) added that 'qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem'. Qualitative methodology generally involves listening to the participants' voice and subjecting the data to analytic induction (e.g., finding common themes) and is exploratory in nature (Creswell 2012, Creswell 2014). Qualitative data may be obtained through interviews, open-ended questionnaires, observations, and content analysis. For this study the qualitative data was obtained through interviews, and classroom observations.

3.2.2.4.1 Description of Observations

A researcher could gather field notes by conducting an observation as a participant observer or as a non-participant observer (Creswell, 1998). Merriam (2001) is of the opinion that observation becomes a research tool if it serves a formulated research purpose, if it is planned deliberately, if it is recorded systematically, and if it is subjected to checks and controls on validity and reliability. Ary, Jacobs and Razavieh (2002) is however of the belief that the best way to enhance validity is to carefully define the behaviour to be observed. 'A primary characteristic of observation is that it involves the direct study of behaviour by simply watching the subjects of the study without intruding upon them and recording certain critical natural responses to their environment' (Rea and Parker, 1997, p. 3). For this study, classroom observation schedules were designed to collect data on the teaching strategies teachers used to integrate the MEP into Jamaican primary classrooms.

3.2.2.4.2 Description of interviews

Merriam (2001) stated that interviews are used to collect information that cannot be observed directly, and interviews are necessary when the required information such as feelings, beliefs, perceptions and opinions cannot be observed. For this research the interviews were designed to obtain information on the teaching strategies employed by the participating teachers, the barriers to integrating the MEP and the impact of the MEP on students' attitude and disposition towards mathematics. As put forward by Merriam (2001), interviewing is the best technique to use when conducting intensive studies of a few selected individuals. The one-to-one semi-structured research format was employed in this study. Semi-structured interview formats as defined by Merriam

(2001) are interviews where it is assumed that individual respondents define the issues in unique ways.

3.3 RESEARCH SETTING, BACKGOUND AND PARTICIPANTS

3.3.0 Introduction

This research was conceptualized and implemented as a follow-up intervention to the Subject Knowledge Enhancement (SKE) programme. After teachers were trained and certified in SKE, separate meetings were held with the senior management of the participating schools to discuss the possibility of staff participating in a collaborative research project that focused on the integration of a MEP in Jamaican primary mathematics classrooms. Sensitization meetings were then held with the teachers. During these meetings, an outline of the proposed research project was given to the teachers and an invitation was made to those who wished to participate. Following this, seven grade 1 teachers, and five grade 2 teachers who were trained in SKE agreed to participate in the project.

For the comparison group, schools that had students performing mathematically at the same level as students of the intervention group were identified and meetings held with principals and teachers. During the meetings the possibility of staff participating in a MEP integration as part of a comparison group was discussed. Also, teachers were fully sensitized on the project and the proposed research project was outlined to the teachers. An invitation was made to those who wished to participate and be trained in SKE. Following this, four grade 1 teachers and three grade 2 teachers agreed to participate as part of comparison group and be trained in SKE. It was originally intended for the number of participants in both the intervention and comparison groups to be the same or as similar in size as possible. The comparison group was however smaller than the intervention group because some teachers chose not to participate in the project if they were not going to be part of the intervention group.

The participating teachers from both the intervention and comparison group had very similar qualifications and teaching experiences. Five of the seven grade 1 teachers from the intervention group had Bachelor of Education degrees in primary education. The other two teachers had Diploma in Primary Education. Six of the seven first-grade teachers had 3 to 6 years of teaching experiences and the other teacher had 18 years of teaching experience. The five grade 2 teachers from the intervention group had Bachelor of Education degrees in primary education and their teaching experiences ranged from 2 to 7 years. Three of the four grade 1 teachers from the comparison group had Bachelor of Education degree in primary education and one teacher had a Diploma on Primary Education. The teaching experiences of the grade 1 teachers from the comparison group ranged from 2 to 6 years. The three grade 2 teachers from the comparison group had Bachelor Education degrees in Primary Education. Their teaching experiences were 5, 6 and 13 years.

In embedded quasi-experimental research designs such as this, teachers and researchers work cohesively to implement a pre-test-intervention-post-test design and a supportive qualitative strand (Creswell 2003; Creswell 2006a, Creswell 2006b; Creswell 2014). The researcher having worked previously with the teachers in the SKE programme helped in creating an avenue for future collaboration. The participating teachers were very supportive and open to change and new challenges. This allowed teachers to embrace the integration of the MEP and the researcher’s presence in their classrooms.

3.3.1 Description of Schools

This embedded quasi-experimental research was conducted at 5 primary schools (3 intervention schools and 2 comparison schools) from representative areas in Jamaica. The participating schools that formed the intervention group were conveniently chosen from the set of schools who had teachers trained in SKE and were not benefiting from any government support through the mathematics coaching programme. As many other experiments, this research project chose convenience sampling because there was a need to investigate naturally formed groups (Creswell, 2014); thus, this study employed an embedded quasi-experimental research design. School A is located in Kingston, Jamaica, School B is located in Manchester, Jamaica and School C is located in Clarendon, Jamaica. The schools represent 3 of the five different classes (lower, middle and upper) of schools in Jamaica. Jamaican primary schools are categorised into five classes based on the number of students enrolled. The number of students enrolled in a class 1 school is at most 250. Classes 2, 3 and 4 have student enrolment ranging from 251 – 500, 501 – 850 and 851 – 1200 respectively. A class 5 school has more than 1200 students enrolled. Participants from the comparison group were selected from two schools from Manchester in Jamaica. These schools were also selected from the set of Jamaican primary schools that were not supported with mathematics coaching assistance. The teachers from the comparison group were also trained in SKE. Students from both the intervention and comparison groups generally came from the poor to middle socio-economic backgrounds. Most of the students are of a black Jamaican ethnicity. Other ethnic groups represented included Chinese and Indian descent. Table 3.2 summarizes the key characteristics of the participating schools in both groups.

	School	Gender	School Organization	Class	Enrolment	Number of Teachers	Pupil/Teacher Ratio
Intervention Group	A	Co - Educational	Whole day	iii	700	22	39:1
	B	Co - Educational	Whole day	i	151	11	19:1
	C	Co - Educational	Shift	v	1441	48	34:1
Comparison Group	X	Co - Educational	Whole day	iii	514	21	25:1
	Y	Co - Educational	Whole day	i	122	8	20:1

Table 3.2 Key Characteristics of the Participating Schools for Both the Intervention and Comparison Groups.

3.3.2 Description of Participants

The sample that formed the intervention group for this embedded quasi-experimental research design was selected from three primary schools from three different parishes in Jamaica. A total of 331 grades 1 and 2 students and 12 teachers were conveniently selected for the intervention group. The grade 1 participants consisted of 189 students and 7 teachers, and the grade 2 participants consisted of 142 students and 5 teachers. The participants from school A were 57 grade one students and 2 teachers, and 31 grade 2 students and 1 teacher. School B had 16 grade 1 students and 1 teacher, and 18 grade 2 students and 1 grade 2 teachers participating in the study. The participants from school C were 116 grade 1 students and 4 teachers, and 93 grade 2 students and 3 teachers. A total of 180 grades 1 and 2 students and 7 teachers were conveniently selected from two schools for the comparison group. The grade 1 participants consisted of 100 students and 4 teachers and the grade 2 participants consisted of 80 students and 3 teachers. School X had 87 grade 1 students and 3 teachers and 58 grade 2 students and 2 teachers participating in the comparison group. School Y had 23 grade 1 students and 1 teacher and 22 grade 2 students and 1 teacher participating in the comparison group. The average age of the grade 1 participants from both groups was 6.5 years with a standard deviation of 3 months. The average age of the grade 2 participants from both groups is 7.4 years with a standard deviation of 3 months. All the participating students selected were learning the respective grade standards in mathematics established by the Ministry of Education based on termly pacing guides.

3.4 RESEARCH PROCEDURE

3.4.0 Introduction

Approval to conduct this research was obtained from the Education Research Ethics Sub-committee of the University of Plymouth (reference number 17/18-209). The researcher, through the Centre of Excellence in Mathematics Teaching (CCEMAT) at the Mico University College, collaborated with The Centre for Innovation in Mathematics Teaching (CIMT) at the University of Plymouth and trained the participating teachers in SKE. The researcher has a great interest in positively impacting mathematics education in Jamaica. She also has a great interest in mathematics enrichment programmes. Through the collaboration with CIMT, she learnt about the MEP and consulted with the Centre's director about the possible adaptation of the MEP for Jamaican Mathematics classrooms. Prior to the study, she was sensitized and trained in the integration of the MEP in mathematics classroom by the director of CIMT, observed the MEP being integrated in English mathematics classes, familiarized herself with the MEP and its features, and lesson study and its role in a MEP. She spent several months conducting a pilot study to test the instruments for integrating the MEP in Jamaican primary mathematics classrooms. During this process, the MEP resources, research instruments such as children's mathematics attitudinal surveys (See Appendix H) and MEP tests (appendix E) were tested. Most importantly, the researcher was able to obtain constructive feedback from teachers who participated in the pilot study. This feedback served as a guide for modifying the MEP to fit the Jamaican context. All efforts and experiences allowed her to adapt, tailor and implement the MEP into Jamaican primary mathematics classrooms. The pilot lasted for 9 months and the field research for the main study lasted for 12 months (3 months of pre-observation and 9 months of intervention and collection of data). Following the field research, the data was analysed using Nvivo 12 and SPSS version 25. The findings from the main research were then discussed in relation to the empirical literature. Subsequently, conclusions, and recommendations for future research and practice were made.

3.4.1 Adaptation of the MEP

Permission was granted by the Centre for Innovation in Mathematics Teaching (CIMT), at the University of Plymouth, for the researcher to adapt, tailor and implement the MEP into Jamaican Primary Mathematics classrooms. The researcher had to take the initiative to learn about the programme and all the key features of the programme. CIMT made the MEP resources available for the researcher to analyse and to determine the extent to which the resources could be integrated in Jamaican primary mathematics classrooms. A detailed analysis of the Jamaican primary mathematics curriculum for grades 1and 2 aimed at determining the extent to which the MEP could meet the learning targets of the curriculum was done. It was found that the content of the MEP resources would adequately cover the content covered at grades 1 and 2 in Jamaica. After this detailed analysis was done, the researcher spent approximately 4 months working with Ms. Elizabeth Holland and Professor David Burghes from CIMT to ensure that the MEP books were fully aligned to the Jamaican Mathematics Curriculum. Modifications were done to ensure that the Jamaican students could relate to the content covered. Modifications made included, but were not limited to:

- ensuring that the content covered in each book was aligned to the Jamaican grades 1 and 2 curriculum and pacing guide.
- adjusting the sequence of the original MEP lessons to fit the flow of lessons as outlined by Jamaica's Ministry of Education's pacing guide for grades 1 and 2.
- making changes to certain words and phrases in the original MEP workbook.

For instance, 'pounds' were changed to 'dollars', and it was also ensured that all work that dealt with telling the time was modified to reflect the 12-hour clock.

Examples of the modifications are shown in table 3.2.

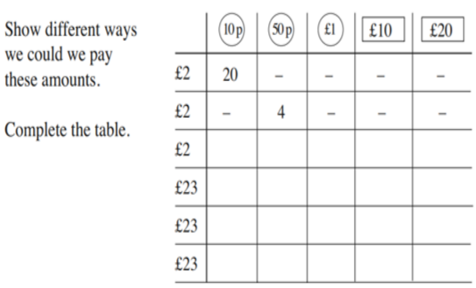
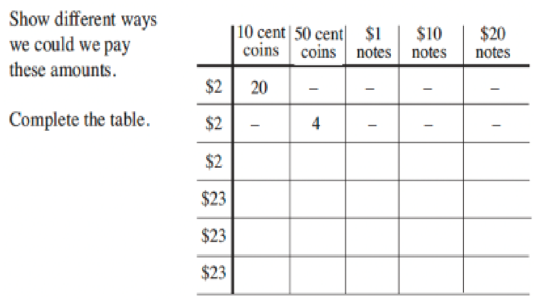
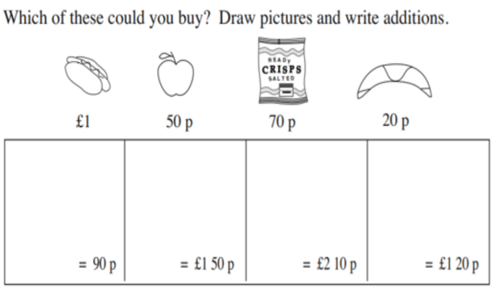
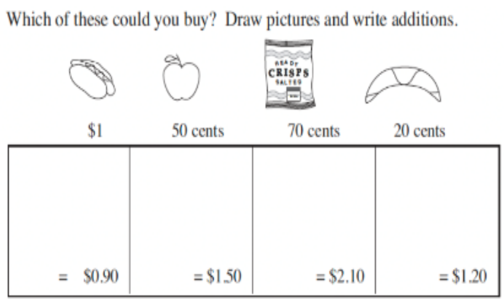
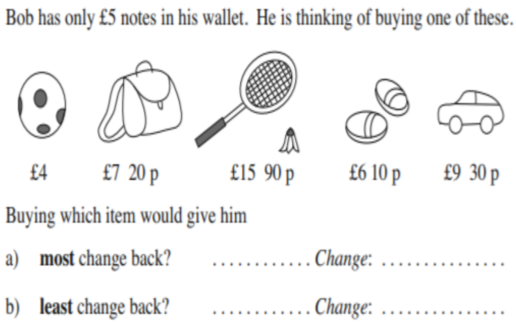
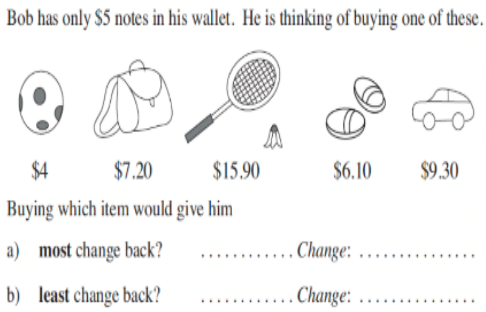
<table>
<tr><th>Original MEP Activity (adapted from 'Mathematics Enhancement Primary Resources' (CIMT, no date)</th><th>Modified MEP Activity</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Table 3.3 Examples of how the MEP Activities were Modified

Following this, a pilot study was carried out with the MEP resources to gain further insight on how suitable the modified MEP workbooks were in terms of structure, sequence, and language and to inform further modifications of the workbooks.

3.4.2 Visiting Schools in England that Implemented the MEP

To be able to effectively guide participating teachers on how to effectively integrate the MEP into Jamaican Primary Mathematics classrooms it was important for the researcher to gain first-hand experience of the implementation of the MEP into primary mathematics classes. It was based on this premise that the researcher, with the help of her director of studies, planned, arranged, and visited schools in England that used the MEP resources. This field visit took place between late October and early November of the calendar year 2017. Three primary schools and one secondary school who were active participants in the MEP were visited. During these visits, the researcher was able to observe key features of the MEP being implemented in mathematics classrooms and was able to have dialogue with the teachers about their experiences teaching in the MEP.

3.4.2.1 Observing MEP Lessons in English Mathematics Classrooms

The English classrooms visited by the researcher were very print rich and organized. The atmosphere created in the classrooms was welcoming and students were able to share in a non-confrontational setting. It was noted that all students were seated so that they had direct eye contact with the teachers and the instructional aids being used. All students were adequately furnished with their MEP resources before the start of instructions.

It was observed that all the teachers were adequately prepared for their lessons and for possible challenges, difficulties, or problems that they might encounter throughout the lesson. Problems encountered by the teachers included students' misconceptions of concepts and students not thinking critically or applying their critical thinking skills. Teachers were able to expand on concepts to enable clarity for all learners and were able to guide students through the steps involved in problem-solving to further build, and in some cases activate students' critical thinking skills. During the lessons, the teachers modelled whole class interactive teaching, did demonstrations, and lead the whole class discussions. Teachers maintained the correct use of mathematical language throughout the instructions. At intervals, student representatives demonstrated how they arrived at given answers or explained their answers while the class engaged in interactive review of given exercises. Students' ability to remain actively engaged through the fast-paced lessons, while demonstrating mastery on the assigned tasks stood out during the researchers' visit.

3.4.2.2 Points Noted from the Lesson Observations/Reflecting on the Experience

The observations provided the researcher with first-hand experience of what is expected when implementing the MEP. She learnt that the key to gaining optimal benefits from the MEP is when teachers adequately prepare themselves for the lessons to be delivered and for possible challenges that may be encountered. It was observed that the MEP lessons employed the spiral curriculum which aids in building students' retention of learnt concepts. This was evident in the level of interactivity students had with the material, how they applied previously learnt concepts to explore new concepts and how they solved given problems. It was also made clear that for the MEP to be effectively implemented, the atmosphere created by the teachers must be friendly and non-confrontational. The teacher in his/her instructions will also need to ensure that he/she provides the correct visuals that supports the MEP lesson being developed, fosters whole class interactive teaching and reviews and be very keen on pacing. It was evident that the MEP was revolutionizing mathematics classrooms and this motivated the researcher to continue with the adaptation of the MEP for implementation into Jamaican primary mathematics classrooms.

3.4.3 The Pilot Study

The MEP was piloted during the period September 2017 to June 2018. The pilot study employed a quasi-experimental research design. The participants for the pilot study were selected from the set of Jamaican primary school teachers who were successfully trained in SKE. The sample for the intervention group consisted of 150 1st grade students and seven teachers from two primary schools in representative areas in Jamaica. The comparison group consisted of 50 grade one students and two teachers from one primary school in Jamaica. The average age of the participants from both groups was 6.5 years with a standard deviation of 3 months. Prior to the pilot, the researcher presented an introduction about the research and the MEP programme to the school principals and teachers. Parents and students were later sensitized and introduced to the MEP. Consent forms were then distributed to teachers, parents, and students to sign. The pilot study was aimed at fulfilling two major tasks: piloting the MEP resources for implementation into Jamaican primary classrooms and the Children's Mathematics Attitudinal Survey.

3.4.3.1 Piloting the MEP Resources

Participating teachers of the piloted intervention group integrated the use of the MEP resources in at least three mathematics lessons per week. The MEP resources used in the pilot study included:

- Mathematical Reasoning Practice Books (each student was given a copy)
- Teacher Support Booklets with detailed lesson plans for each lesson in the mathematical reasoning practice books.
- number lines (class and individual)
- number cards
- shape cards.

Before this integration, it was ensured that the subject knowledge of all the participating teachers of the intervention group was enhanced (teachers were trained and certified in CIMT's Subject Knowledge Enhancement Programme). The participating teachers were then trained on how to integrate the MEP into their mathematics classrooms. This training focused on sensitizing the participating teachers of the key points of the MEP (see table 2.1 on page 44), and the recommended MEP pacing. Teachers were also exposed to various approaches that may be employed to incorporate the MEP resources in their math lessons.

The following are key points of the MEP that were emphasized at all training sessions. The MEP:

- uses problem-solving as a major strategy in the teaching of mathematics
- puts the teacher as the focus of the learning
- encourages correct, precise, orderly spoken, and written mathematics
- places greater emphasis on whole-class, interactive teaching with less differentiation and less individual work
- promotes mental mathematics, including knowledge of basic addition and multiplication facts

On each classroom observation it was ensured that the participating teachers were adhering to these key principles. Additionally, continuing professional developmental sessions were undertaken with the participating teachers throughout the intervention. The pilot study provided the opportunity for the researcher to observe and reflect on the integration of the MEP in Jamaican primary classrooms. It allowed for the researcher to see how comfortable teachers and students were in interacting with the MEP resources. Through classroom observations and feedback sessions, the researcher was made aware of potential challenges associated with the integration. Knowledge of potential challenges enabled the researcher to design and implement measures to mitigate these challenges in the main study. Overall, the findings from the pilot study were used to inform how the MEP could be further tailored to enable for its effective integration into Jamaican primary classrooms.

3. 5 ETHICAL CONSIDERATIONS

3.5.0 Introduction

Ethical considerations are an important aspect of social research. As put forward by Cohen, Manion and Morrison (2000), when conducting a research, ethical issues must be considered because they protect the researcher and participants of the research from potential harm that may be caused because of the research. This study was designed and conducted based on the ethics guidelines of the University of Plymouth. Also, ethical approval was sought and obtained prior to the collection of data. The ethical principles which guide the activity of educational researchers such as informed consent, openness, protection from harm, confidentiality and privacy follow the guidance outlined by the British Educational Research Association (BERA, 2018). This section gives an overview of the ethical principles considered for this study.

3.5.1 Informed Consent

Informed consent is the condition through which participants understand and agree to their participation, and the terms and practicalities of it, with no duress, prior to the research getting underway (British Educational Research Association [BERA], 2018, p.9). David, Edwards and Alldred (2001) suggested that informed consent is very important to ethical research, and it is the process by which the researcher presents adequate information that provides sufficiently for the participants to know and understand what they are agreeing to be a part of. This view was expanded by the BERA (2018) when it was outlined that the researcher should do everything that will ensure that all potential participants understand, as well as they can, what the study entails, why their participation is necessary, what they will be asked to do, what will happen to the information they provide, how the information will be used and to whom it will be reported. BERA (2018, p. 9) added that 'It is normally expected that participants' voluntary informed consent to be involved in a study will be obtained at the start of the study, and that researchers will remain sensitive and open to the possibility that participants may wish, for any reason and at any time, to withdraw their consent'. Informed consent was a key part of this study. For this research, informed consent was solicited from school administrators, teachers, parents and students. Also, in keeping with the recommendations of David, Edwards and Alldred (2001), the need for consent to be re-negotiated were emphasized and discussed throughout this study.

Discussions were firstly held with the school administrators of each of the participating primary schools, followed by discussions with all potential participating teachers. These discussions were followed by meetings with both the school administrators and the teachers. These discussions focused on outlining the key features of the project and providing an overview of what participating in the project would entail. Opportunities were also provided for school administrators and teachers to ask any questions. Potential harms were considered by the researcher prior to the discussions so that they could be discussed with the participants. These included feelings of discomfiture from being observed by the researcher, lesson study sessions, collective or individual feedbacks from observations and the researcher analysing and discussing students' current competency levels in mathematics with the participating teachers. Additionally, the potential participants were made aware of the benefits of being involved in the study, which aided in creating an avenue for the teachers to consider both the risks and potential outcomes associated with the research project.

Following the initial discussions, school administrators were provided with the information sheets related to this research project (appendix A). The information sheet provided detailed descriptions of the project, what participants will do if they decide to participate in the project, informed consent, the right to withdraw, advantages and disadvantages of participating in the project, debriefing, confidentiality, planned outputs, data storage and feedback. School administrators and teachers were asked to complete written consent forms (appendix B) after reading the information sheets.

For this study, informed consent was also obtained from the parents/guardians and the students. Children should be given the privilege to self-select and make the decision to participate in research rather than that given of their parents and/or their teachers (David, Edwards, and Alldred, 2001, p. 348). BERA (2018, p. 15) stated that 'children who are capable of informing their own views should be granted the right to express those views freely in all matters affecting them, commensurate with their age and maturity'. Equally, as outlined by BERA (2018), researchers also need to take into consideration the rights and duties of those who have legal responsibilities for children, such as those who act in guardianship. The researcher, in the presence of the school administrators and the teachers met with the parents and discussed the research project with them. This was followed by parents being provided with the information sheet that detail the terms and conditions of the research project. Parents were then asked to complete written consent forms. Following approval from parents, the project was then discussed with students in their classrooms including the opportunity for the students to ask any questions. They were then provided with a student information sheet and consent forms. Informed consent was maintained throughout this research project by soliciting verbal consent from the students prior to focus group interview and making them aware of the right to choose whether to answer the questions.

3.5.2 Anonymity and Confidentiality

Anonymity and confidentiality within the context of research seeks to protect the privacy of the participants. Coffelt (2017) is of the opinion that anonymity and confidentiality are ethical practices designed to protect participants while data are being collected, analysed, and reported. Researchers should recognize the entitlement of both institutions and individual participants to privacy and should accord them their rights to confidentiality and anonymity (BERA, 2018, p. 21). Anonymity as defined by Coffelt (2017) is the process by which the identity of the participants is protected, and data is collected without obtaining personal and identifying information. Confidentiality as outlined by Coffelt (2017) refers to separating or modifying any personal, identifying information provided by participants from the data and ensuring that all data collected will only be used for the purpose of the research.

BERA (2018) suggested that there is a need to consider anonymity in research that uses visual methodologies and participatory methods. The researcher should provide an agreement that secures very clear conditions regarding anonymity and about subsequent use of data (BERA, 2018, p. 22). In this research, all the information gathered protected the identify of all the participants. For this research, anonymity was ensured by assigning participating schools, teachers, and students pseudonyms within the wider dissemination of the project. To further enforce anonymity, only relevant information has been provided concerning the schools, participating teachers, and students.

3.5.3 Ethical Considerations in Quasi-Experimental Research

To examine the impact of the MEP on primary mathematics education in Jamaica, it was necessary to establish a cause-and-effect relationship between the independent and dependent variables (Thomas, 2022). Within this embedded quasi-experimental research design, the MEP lesson integration was offered to the intervention group and withheld from the comparison group to determine any differences in students' attitude and performance in mathematics on the post assessments (Creswell, 2014). As put forward by Thomas (2022), quasi-experiments allow one to study causal relationship without ethical issues. It is however important that the comparison group be offered the treatment after the causal relationship is fully studied (Creswell, 2014; Thomas 2022). The participants that formed the comparison group for this research will be offered the treatment at a later date. This had been delayed due to the Covid 19 pandemic.

3.6 DATA COLLECTION MAIN STUDY

3.6.0 Introduction

This section describes the research timeline for data collection and the data collection methods employed within the main study. The data for this study was collected using classroom observations, pre-tests, post-tests, pre- and post-children's mathematics attitudinal surveys, teacher interviews and focus group interviews with students.

3.6.1 Research Timeline

Table 3.4 outlines the research programme during the study from initial observations to the point of withdrawal from the schools.

Date/Period	
2018 – Term 3	
April – July 2018	• Observations prior to the MEP training • Meeting with management team at each school to discuss the research proposal • Invitation to teachers to join the research project • Information sheets and consent forms provided for principals and classroom teachers.
August	• Train participating teachers on how to integrate MEP in their mathematics classrooms
2018 Term 1	
September 2018 Weeks 2 - 3	Teacher participation reconfirmed – further information sheets and consent forms provided for teachers Information sheets and consent forms provided for parents and participating students (Week 1) Pre- testing Administration of pre- children's Mathematics Attitudinal Survey Introduction of reception books to grade 1 Introduction of year two materials to 2nd graders Introduction to lesson study
September 2018-December 2018 (Weeks 4 -15)	• Integration of MEP in Jamaican **grades one and two** mathematics classrooms ❖ Participating teachers developed mathematical concepts in their grades one and two classes by integrating the MEP into their daily mathematics lessons. • Data collection in classrooms and classroom observations.
December 2018 (Week 14)	• Reflection session with teachers • Lesson study sessions • Continuing Professional Developmental session with teachers
Term 2 2019	
January – March (weeks 2-14)	• Integration of MEP in Jamaican **grades one and two** mathematics classrooms ❖ Participating teachers developed mathematical concepts in their grades one and two classes by integrating the MEP into their daily mathematics lessons. • Data collection in classrooms and classroom observations.
Weeks 6 & 12	• Reflection session with teachers • Lesson study sessions

	• Continuing Professional Developmental session with teachers
Term 3 April - June (2 – 10)	• Integration of MEP in Jamaican **grades one and two** mathematics classrooms ❖ Participating teachers developed mathematical concepts in their grades one and two classes by integrating the MEP into their practice. • Data collection in classrooms and classroom observations.
Week 5	• Reflection session with teachers • Lesson study sessions • Continuing Professional Developmental session with teachers
June (Weeks 8 – 10)	• Administration of Post-tests • Administration of Post- children's Mathematics Attitudinal Survey • Focus Group Interviews • Teacher Interview

Table 3.4 The Research Timeline

3.6.2 Data Collection Methods

The data for this study was collected by means of pre-test, post-test, classroom observations, lesson plan intervention, pre- and post- children's mathematics attitudinal surveys, focus group interviews and teacher interviews.

3.6.2.1 Pre-tests

Pre-tests were administered to participants from both the intervention and comparison groups prior to the intervention. The adapted MEP test 0 was administered as the pre-test to the grade 1 participants. This test consisted of 4 questions with a total of 10 marks. The MEP test 1 was administered as the pre-test to the grade 2 participants. Test 1 consisted of 7 questions with a total of 20 marks (10 marks from test 0 and ten new marks). Both tests were geared at measuring students understanding of number concepts.

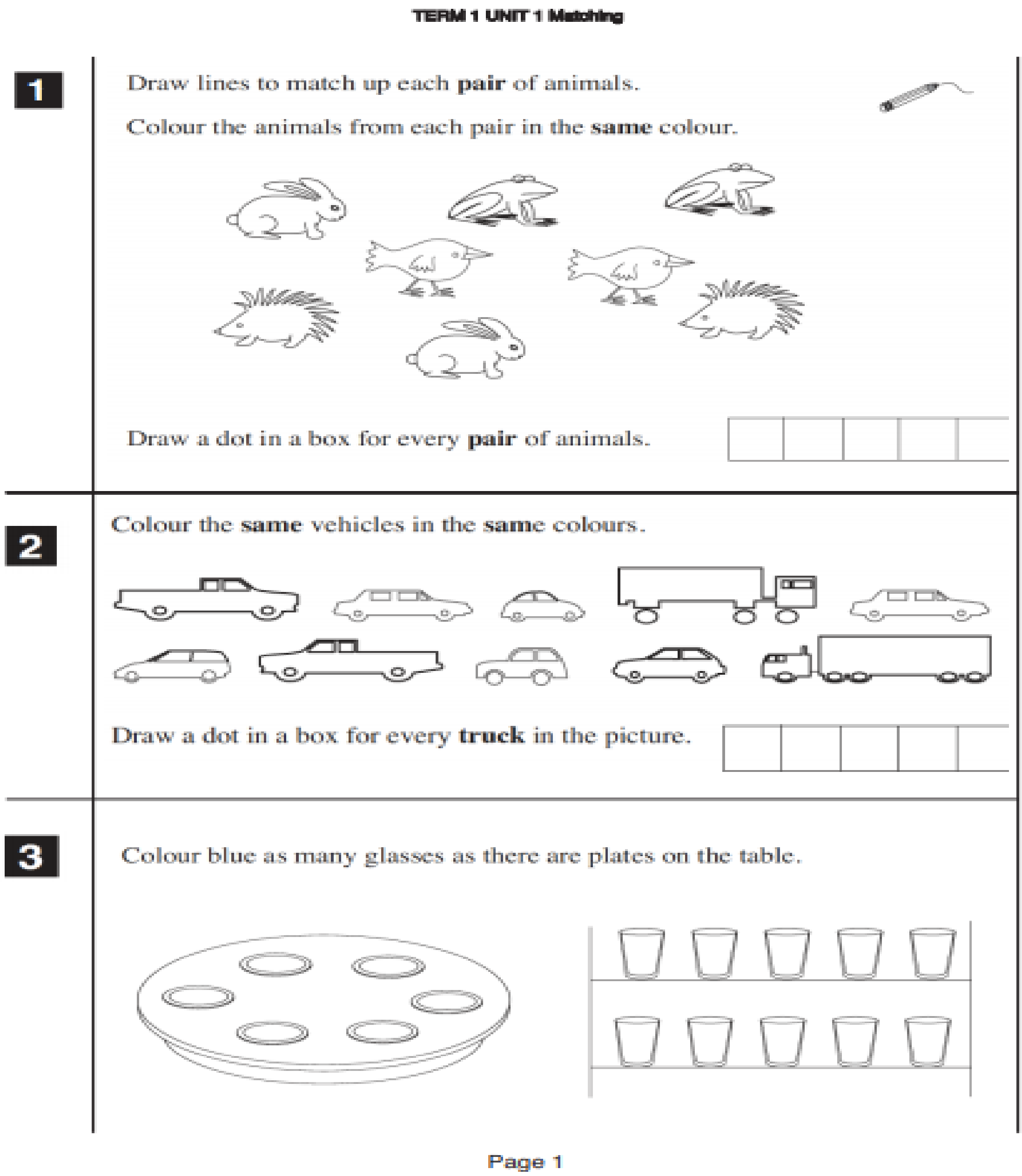
3.6.2.2 Pre- Children's Mathematics Attitudinal survey

The pre- children's mathematics attitudinal survey was administered to the participants from both the intervention and comparison groups. The survey was geared at measuring students' perceptions and attitudes towards mathematics prior to the intervention. It consisted of 10 questions which evaluated how students viewed mathematics in terms of affection, difficulty, and relevance prior to the intervention. This instrument was created by the researcher and was piloted during the pilot phase of the research to check for the validity of the instrument. The children's mathematics attitudinal survey also applied Likert three-point scale (appendix H). The pilot tested for content validity, do scores predict a criterion measure or do results correlate with other results (Creswell, 2014). In accordance with Creswell (2014, p. 205), establishing validity of the scores in a survey helps to identify whether an instrument might be good to use in survey research.

3.6.2.3 Intervention

During the period September 2018 to June 2019, the participants from the intervention group were taught mathematics daily using the MEP resources. The sequencing of the lessons in each of the MEP's mathematical reasoning workbook were fully aligned to the grades 1 and 2 termly standards outline recommended by Jamaica's Ministry of Education for the 2018-2019 school year. More specifically, the grades 1 and 2 participants from the experimental group were respectively taught the Jamaican grades 1 and 2 mathematics standards daily using the adapted MEP resources. Through lesson study sessions and continued professional development sessions the participating teachers were able to develop the requisite skill sets needed to facilitate the integration of the MEP in their mathematics lessons. The participating teachers were also able to choose the teaching strategies that they saw relevant to their teaching style and that would cater for the needs of their students as they integrated the MEP into their lessons.

Figures 3.2 and 3.4 are examples of the adapted and tailored lessons incorporated in the Jamaican Primary classrooms. Figures 3.3 and 3.5 are the teacher support lesson plans for the sample MEP lesson.


TERM 1 UNIT 1 Matching

1 Draw lines to match up each **pair** of animals.

Colour the animals from each pair in the **same** colour.

Draw a dot in a box for every **pair** of animals.

2 Colour the **same** vehicles in the **same** colours.

Draw a dot in a box for every **truck** in the picture.

3 Colour blue as many glasses as there are plates on the table.

Page 1

Figure 3.2 Adapted MEP Lesson on Matching (CIMT, no date)

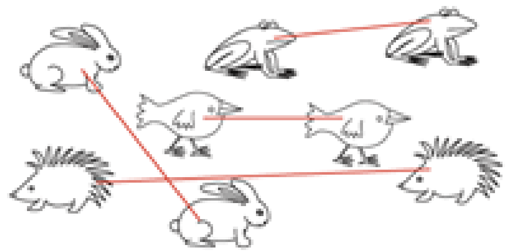
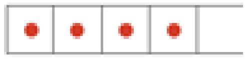
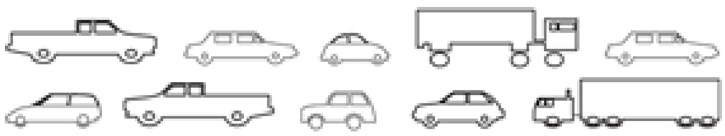
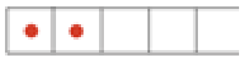
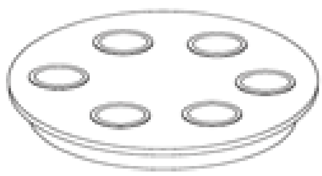
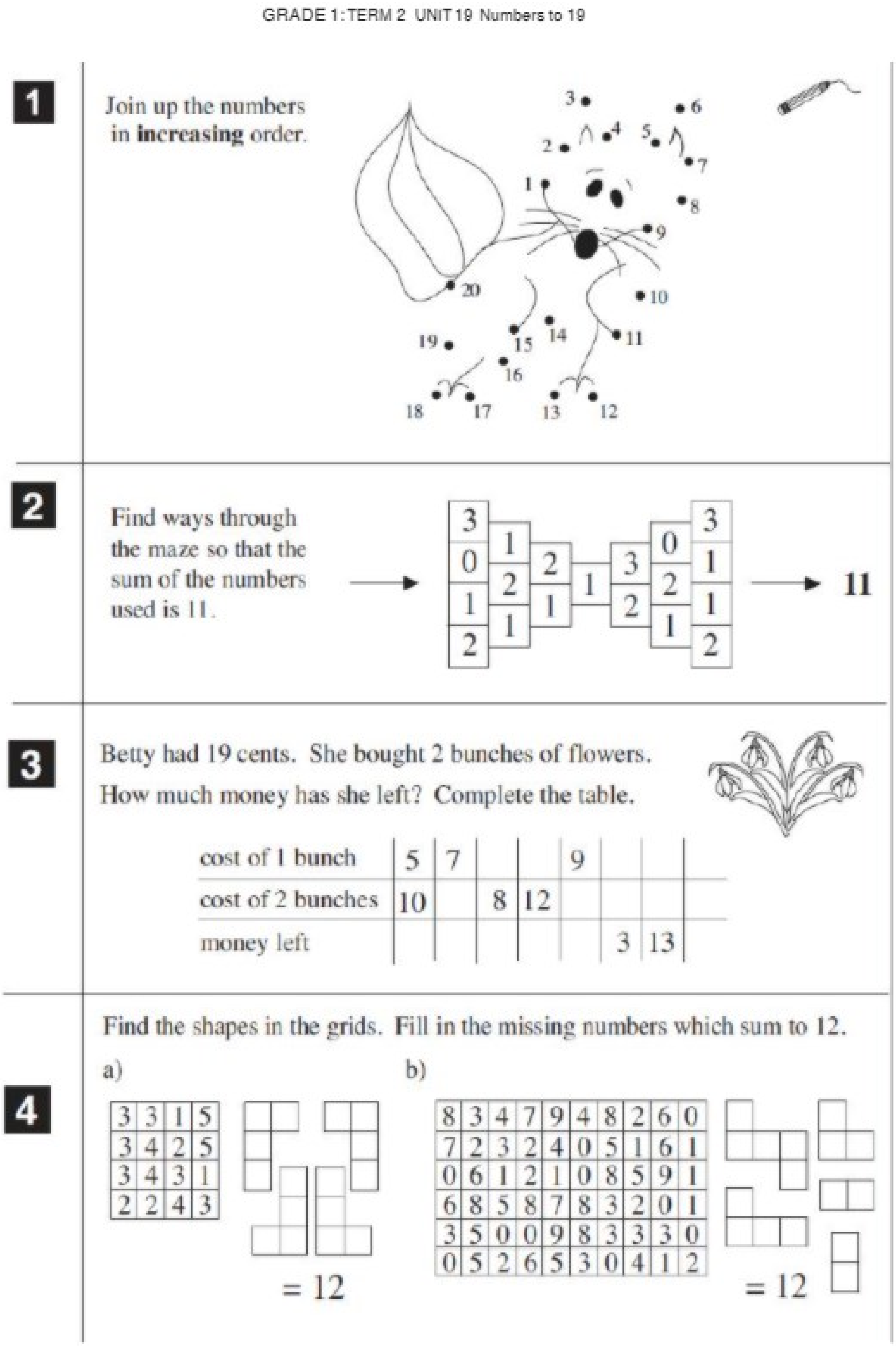
Page 1	Solutions	Comments
1	Draw lines to match up each **pair** of animals.  Colour the animals from each pair in the **same** colour.  Draw a dot in a box for every **pair** of animals.  Lines drawn joining pairs of animals.	Here clarify that "match" means the same animal. A "pair" means two animals that match and there is a dot for each pair. You can extend the question by asking "how many animals are there altogether?" or to name and spell the animals.
2	Colour the **same** vehicles in the **same** colours.  Draw a dot in a box for every **truck** in the picture.  There are only 2 pairs of identical vehicles.	Make sure the learners know what "same" means. Note that only two small trucks are the same as there are differences in the two large trucks. An extension would be to count the total number of vehicles.
3	Colour blue as many glasses as there are plates on the table.  	There are 6 plates on the table and so ANY 6 glasses need to be coloured. You could ask learners for different ways of colouring the glasses.

Figure 3.3 Teacher Support Lesson Plan for the Adapted MEP Lesson on Matching



GRADE 1: TERM 2 UNIT 19 Numbers to 19

1 Join up the numbers in **increasing** order.

2 Find ways through the maze so that the sum of the numbers used is 11.

3 Betty had 19 cents. She bought 2 bunches of flowers. How much money has she left? Complete the table.

cost of 1 bunch	5	7			9		
cost of 2 bunches	10		8	12			
money left						3	13

4 Find the shapes in the grids. Fill in the missing numbers which sum to 12.

a)

3	3	1	5
3	4	2	5
3	4	3	1
2	2	4	3

= 12

b)

8	3	4	7	9	4	8	2	6	0
7	2	3	2	4	0	5	1	6	1
0	6	1	2	1	0	8	5	9	1
6	8	5	8	7	8	3	2	0	1
3	5	0	0	9	8	3	3	3	0
0	5	2	6	5	3	0	4	1	2

= 12

Figure 3.4 Adapted MEP Lesson on Number Concepts (CIMT, no date)

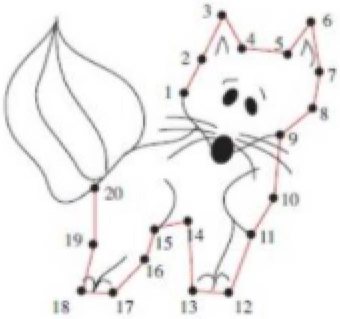
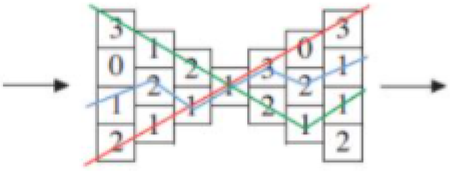
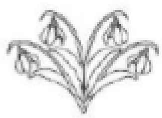
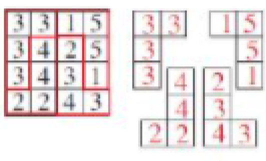
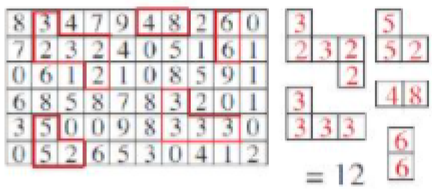
<table>
<tr><th>Page 11</th><th>Solutions</th><th>Comments</th></tr>
<tr><td>1</td><td>Join up the numbers in increasing order.
</td><td>This is an exercise in using the numbers in increasing order, starting from 1, 2,..
Learners need to be careful not to miss out any numbers; you could first write down interactively the number sequence on the board before the learners start.</td></tr>
<tr><td>2</td><td>Find ways through the maze so that the sum of the numbers used is 11.
</td><td>The challenge is to find all the possible routes through the maze that have a total of 11; there are three possible ways.</td></tr>
<tr><td>3</td><td>Betty had 19 cents. She bought 2 bunches of snowdrops. How much money has she left? Complete the table.

<table>
<tr><td>cost of 1 bunch</td><td>5</td><td>7</td><td>4</td><td>6</td><td>9</td><td>8</td><td>3</td><td>2</td></tr>
<tr><td>cost of 2 bunches</td><td>10</td><td>14</td><td>8</td><td>12</td><td>18</td><td>16</td><td>6</td><td>4</td></tr>
<tr><td>money left</td><td>9</td><td>5</td><td>11</td><td>7</td><td>1</td><td>3</td><td>13</td><td>15</td></tr>
</table></td><td>This is a doubling exercise to go from 1 bunch to 2 bunches. Learners also need to take the cost of 2 bunches from 19 cents.
There are also variations in the process, including starting with the money left.</td></tr>
<tr><td>4</td><td>Find the shapes in the grids. Fill in the missing numbers which sum to 12.
a)

b)
</td><td>It is important that your learners can add up 4 (or 3 or 2) numbers accurately to obtain 12; it might be helpful to first get the class to give possible additions sums; for example 3+3+3+3 and 2+2+4+4, etc.</td></tr>
</table>

Figure 3.5: Teacher Support Lesson for the Adapted MEP Lesson on Number Concepts

Coupled with these plans, students were also furnished with the MEP support materials which included:

- Mathematics Reasoning Practice Books
- Number lines
- Number cards
- Shape cards

3.6.2.4 Reflection/Lesson Study/Professional Development Sessions

During this study a total of three (3) reflection/lesson study/professional development sessions were held with each set of participating teachers of the intervention group. These sessions were held at the individual participating schools. The sessions which lasted for an average of 2-3 hours were aimed at:

- gaining insights into participating teachers' comfort level with implementing the MEP into their mathematics classes
- identifying and addressing challenges the participating teachers faced during the integrating of the MEP
- allowing selected teachers to model lessons that integrate the MEP into their classes
- discussing strengths and weaknesses of modelled lesson
- sharing of video snippets of effective mathematics practices from Hungarian teachers
- addressing the needs of participating teachers and providing the necessary support for the effective integration of MEP into Jamaican primary mathematics classes.

These sessions took place in a professional, yet friendly setting. Teachers shared comfortable and were welcoming of the constructive feedback they received.

3.6.2.5 Post-tests

Following the intervention, post-tests were administered to all students from the intervention and the comparison groups. The MEP test 1 was administered to the grade 1 students as their post-test. Test 1 consisted of 7 questions which totalled 20 marks (4 questions and 10 marks are from Test 0 and 3 questions, and 10 marks are new). The MEP test 2 was administered to the grade 2 students as post-test. Test 2 consisted of 17 questions and 40 marks (7 questions and 20 marks from Test 1 and 10 new questions and 20 marks). The post-tests also tested students understanding of number concepts and allowed the researcher to measure the impact the MEP had on students' attainment in mathematics.

3.6.2.6 Post- Children's Mathematics Attitudinal Survey

The same children's mathematics attitudinal survey that was administered prior to the intervention was administered to students from both groups after the intervention. This survey was administered to examine any impact the MEP had on how students' viewed mathematics in terms of affection, difficulty and relevance.

3.6.2.7 Classroom Observations

Classroom observations were employed to help the researcher understand the participating teachers' knowledge of the MEP resources and lessons, the MEP resources that participating teachers integrated into their mathematics classes and the teaching method used to facilitate the integration of the MEP into Jamaican primary mathematics classes. The observations also helped the researcher to measure any difference in students' participation prior to and during the intervention and to examine the extent to which participating teachers integrated the MEP resources in given assignments. A daily lesson observation guide (see appendix J) was used at each session observed.

3.6.2.8 Teacher Interview

A semi-structured interview consisting of ten questions (Appendix N) was used to gather information from the teachers relating to their perceptions of integrating the MEP. Teachers were interviewed individually to gain insights into how they integrated the MEP into their Jamaican primary mathematics classes, the teaching strategies they employed, and the barriers associated with the integration. The interviews also create the avenue for teachers to explain any potential impact they perceive the MEP may have on mathematics education in Jamaica

3.6.2.9 Focus Group Interviews

A semi-structured interview consisting of 6 questions (Appendix P) was used to gather information from students about their experiences learning mathematics during the integration of the MEP into their mathematics classes. One focus group, consisting of 6-10 students was interviewed from each participating school. These interviews allowed the researcher to gain deeper insights into how students' felt about mathematics, attending mathematics classes, what they liked about their mathematics classes, the different things the teachers used to teach mathematics and how the teaching aids used by their teachers helped them to understand mathematics.

3.7 DATA ANALYSIS

The data collected for analysis in this embedded quasi-experimental research comprised of pre-tests, post-tests, pre- and post- children's mathematics attitudinal surveys, classroom observations, teacher interviews and focus group interviews. Quantitative and qualitative data were analysed separately. This session will outline how each form of data was collected and analysed.

3.7.1 Quantitative Data Analysis

The 25^{th} version of SPSS was used to conduct data analysis on the effect of the MEP method versus the traditional teaching methods on attainment in mathematics. The range and variability of scores from both groups on the pre-tests and post-tests were compared using box plots. Chi-squared tests were used to measure the association between progress and the groups. According to Pallant (2007), one-way ANCOVA is one of the three common ways of analysing data based on a pre-test-post-test control group quasi-experimental design. The one-way ANCOVA is favoured when there are pre-test differences between the groups. This is because the ANCOVA model uses the pre-test scores as the covariate, post-test scores as the dependent variable, and the type of group as the fixed factor. That is, this model holds constant any difference in the pre-test scores and evaluates the post-test differences between groups.

To evaluate the pre-test differences between the intervention and the comparison groups, an independent-samples t-test was run to compare the pre-tests scores in both groups. No significant differences were found between the two groups for the pre-tests since $p > 0.05$ (See appendix G). This finding indicated that the students from both groups were initially performing at the same level. A homogeneity of regression test was also conducted, and it was found that there is a linear relationship between the dependent variable and the covariate. Therefore, it was ideal for this research to use a one-way ANCOVA to analyse data collected from the pre-tests and post-tests. Aarts, Akker and Winkens (2013) are of the opinion that it is impossible to compare the effect obtained in given studies using p-values. Kraft (2020) added that interpreting research findings can be challenging when outcomes like academic achievement are measured using unintuitive and arbitrary scaled and recommends converting these measures onto the same scale using the standardized effect size. Aarts, Akker and Winkens (2013) suggested that Cohen's d effect size can be used when comparing the mean value of a numerical variable between two groups. It is based on this premise that this study also evaluated the Cohen's d effect size for the pre- and post-tests for each group.

The pre- and post- children's mathematics attitudinal surveys which applied Likert three-point scale were analysed using comparative summary tables. The summary tables clearly outlined students' feelings towards mathematics before and after the intervention. Comparative bar charts were also used to provide illustrative representation of select questions from the children's mathematics attitudinal survey.

3.7.2 Qualitative Data Analysis

The initial qualitative data analysis was guided by the qualitative research questions. The field notes collected from the focus group interviews, teacher interviews and classroom observations were transcribed and repeatedly read, and the transcripts were revised repeatedly to ensure that reliable record of the data was created (Barron, Pea and Engle, 2013). Coding began by carefully examining the data collected from the classroom observations, teacher interviews and focus group interviews. Re-reading of the transcripts and field notes helped in confirming or refuting the initial codes. Where codes were refuted, other codes were developed. Descriptive and in vivo coding were used to analyse the data using QRS international's NVivo 12 qualitative software programme. Subcodes were then assigned after each primary code to detail and enrich the entry (Miles and Huberman, 1994, p.61). Three initial codes (parent nodes), teaching strategies, students' views, and barriers were generated from the first level coding. Where appropriate, sub-codes were derived for the parent nodes.

Examples of the Nodes and sub-nodes generated are presented in tables 3.4, 3.5, and 3.6

Child Nodes	**Sub-Nodes**
Cooperative Learning	Discovery learning learning groups Dramatization
Discussion	Question and answer sessions Group discussions Whole class interactive discussions Small group discussions
Tangible Resources	Manipulatives Model objects MEP resources
Modelling	Scaffolding Metacognitive Student centred Task and performance
Technology	Computer based instruction Mobile devices Whiteboards Speakers Projectors
Math connect	Real life applicability Other subject connectivity
visualization	Videos Audios Pictures Modelling

Table 3.5 Child Nodes and Sub-nodes for Teaching Strategies

Child Nodes	Sub-Nodes
Learning factor	- Able to solve problems - High grades - Understand math
Neutral	- Sometimes easy, sometimes hard - Sometimes I can solve the maths, sometimes I can't
Students' perception	- Able to solve math problems - Favourite subject - Math is easy - Math is fun - Math is useful
Teacher factor	- Teaching links math to real life - Teacher makes math fun - Teaching method
Teaching Resources	- Activity books - Computers - Real objects - Supporting materials

Table 3.6 Child Nodes and Sub-nodes for Students' Views

Child Nodes	Sub-Nodes
Financial Constraints	- Inability to provide resources
Limited resources	- Limited access to technology - Limited teaching aids and resources - Overcrowded classrooms
Human Factor	- Subject knowledge - Not open to change - Time-consuming

Table 3.7 Child Nodes and Sub-nodes for Barriers

An extract from coding of the transcripts using Nvivo 12 is shown in Appendix Q. The findings from the Nvivo 12 analysis were presented using tables and flowcharts. Analysis from classroom artefacts, probing questions from the children's mathematics survey, the transcript from teachers' interviews and focus group interviews, classroom observations and reflections were used to triangulate the data analysis

3.8 Reliability, Validity and Bias

Reliability deals with the consistency, dependability, and replicability of 'the results obtained from a piece of research' (Nunan, 1999, p. 14). Creswell (2014, p. 295) added that 'Reliability refers to whether scores to items on an instrument are internally consistent (i.e., are the item responses consistent across constructs?), stable over time (test-retest correlations), and whether there was consistency in test administration and scoring'. To ensure reliability, test and retest using pre-test and post-test were used. Reliability was also ensured through the weekly supervision of the MEP integrated lessons taught by the participating teachers. Reliability for the data obtained through the qualitative strand of the research was ensured by checking all transcripts to confirm that they do not contain obvious mistakes during transcription and by ensuring that there was no drift in the definition or meaning of the codes during the process of coding (Gibbs, 2007).

'Validity is an essential criterion for evaluating the quality and acceptability of research' (Burns, 1999, p. 160). As recommended by Merriam (1998), Triangulation is one means of ensuring validity. It aids in strengthening the validity of evaluation of data and findings (Zohrabi, 2013). The collection of data through multiple sources is one way of triangulating data (Creswell, 2014; Zohrabi, 2013). Triangulation is necessary since 'gathering data through one technique can be questionable, biased and weak' (Zohrabi, 2013, p. 258). Validity is deemed high when the findings are similar. For this study, triangulation was applied through the classroom observations, the probing questions from the children's mathematics attitudinal survey and the interviews that were done. Additionally, the researcher asked the interviewees specific questions as a means of checking for understanding of what the interviewee meant.

Eliminating the researcher's bias is another way of ensuring the validity of a research (Merriam, 1998). To eliminate bias, the researcher was as impartial as possible when collecting, analysing, and interpreting data. A concerted effort was also made by the researcher to be non-judgmental and as clear as possible throughout the research process. The ethical rules and principles that governed this research were upheld throughout the research process. The evaluation of the data collected for this research was as accurately evaluated as possible and the finding were honestly reported. Additionally, to avoid bias, the interview questions were open ended and were not skewed towards ascertaining a particular response but instead they allowed the interviewee to freely state their feelings and opinions.

CHAPTER 4

PRESENTATION OF FINDINGS

4.0 INTRODUCTION

This chapter presents the results based on analyses of the quantitative and qualitative data. In general, the quantitative data analysis focuses on seven aspects: variability using boxplots; association of progress scores using Chi-Squared tests; mean scores; standard deviation; pre- and post-tests from each group; effect size using Cohen's d from the pre to post for each group; and alpha values of post-test differences between groups from one-way ANCOVAs. The qualitative data analysis focused on providing answers related to students' attitudes towards mathematics, the teaching strategies used to integrate the MEP into Jamaican primary classes, barriers to integrating the MEP and aspects of the MEP teachers adapted and implemented. Qualitative data is presented in this chapter using flowcharts, tables, lesson extracts and direct quotes of teachers' experiences. The results presented in this chapter addressed the six research questions that this study was guided by. The guiding research questions of this study are:

1. How does the implementation of the MEP impact students' performance in mathematics?
2. How does the implementation of the MEP impact students' attitudes and disposition to mathematics education?
3. What teaching strategies are used in implementing the MEP in mathematics classes?
4. What do teachers consider as the most effective teaching strategies for implementing the MEP in mathematics classes?
5. What do teachers consider to be the barriers to incorporating MEP resources and teaching strategies in Jamaican Primary Classrooms?

6. Which aspects of the MEP do teachers think they will adapt and implement in their own practice?

4.1 THE IMPACT OF THE MEP ON STUDENTS' PERFORMANCE IN MATHEMATICS

The first research question was aimed at examining the effect the implementation of the MEP in Jamaican mathematics classes had on students' attainment in mathematics. To answer this question, results from the pre-test and the post-test were analysed using SPSS version 25. The results are shown in the figures and tables below.

4.1.1 Results from the Grade 1 Participants

Figure 4.1.1 shows that for the pre-test (test 0), the intervention group had a median score of 4 and the comparison group had a median score of 5. This is an indicator that for the pre-test, the median score of the intervention group is less than the median score of the comparison group. The range of scores for the intervention group is 9 (that is from 0 to 9) and the interquartile range is 3 while the range of scores for the comparison group is 9 (that is from 0 to 9) the interquartile range is 3.5. That is the pre-test score variability of the intervention group is less than that of the comparison group. For the intervention group, the lower 25% of the scores lies between 1 and 3, the middle 50% of the test scores of the lies between 3 and 6 the upper 25% of scores lies between 6 to 9. For the comparison group the lower 25% of the scores lies between 0 and 3, the middle 50% of the test scores of the lies between 3 and 6.5 the upper 25% of scores lies between 6.5 and 9. Overall, the attainment of the participants from the intervention and comparison groups were initially very similar.

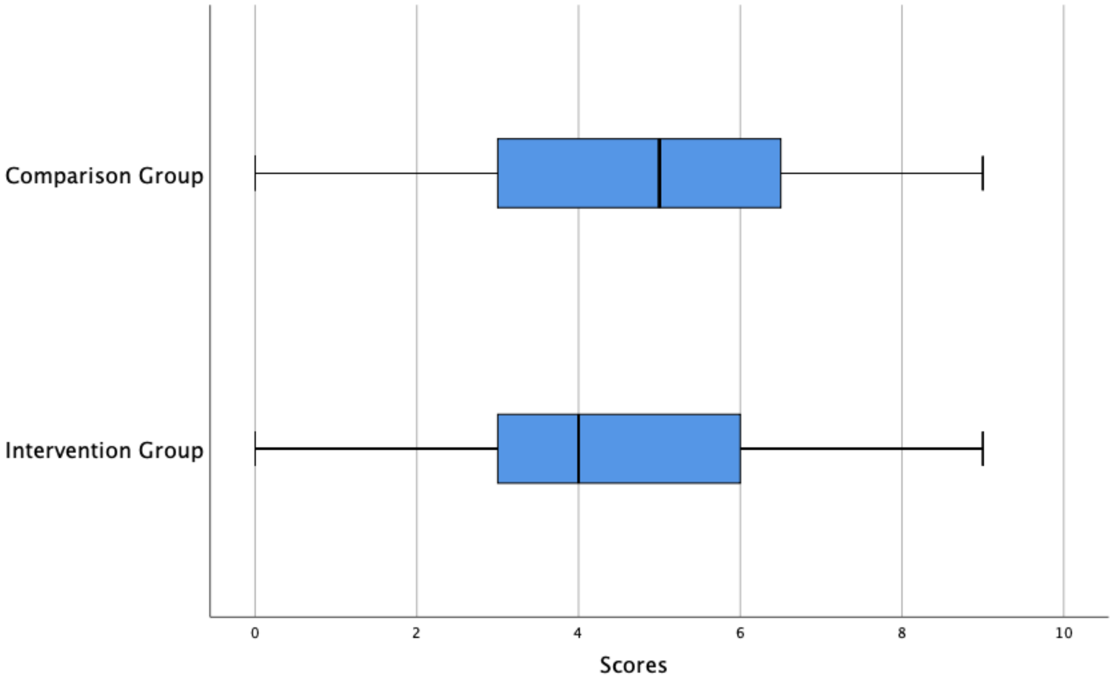


Figure: 4.1.1 Double Boxplots Showing the Results of the Pre-test (test 0) for the Intervention and the Comparison Groups for the Grade 1 Participants.

Figure 4.1.2 shows that for the post-test (test 1) for the grade 1 participants, the intervention group had a median score of 12 and the comparison group had a median score of 9. This is an indicator that for the post-test, the median score of the intervention group is greater than the median score of the comparison group. The range of scores for the intervention group is 17 (that is from 3 to 20) and the interquartile range is 7 while the range of scores for the comparison group is 18 (that is from 0 to 18) and the interquartile range is 7. The post-test variability score of the intervention group is less than that of the comparison group. For the intervention group, the lower 25% of the scores lies between 3 and 12, the middle 50% of the test scores lies between 8 and 15 and the upper 25% of scores lies between 15 and 20. For the comparison group the lower 25% of the scores lies between 0 and 6, the middle 50% of the test scores lies between 6 and 13 and the upper 25% of scores lies between13 and 18.

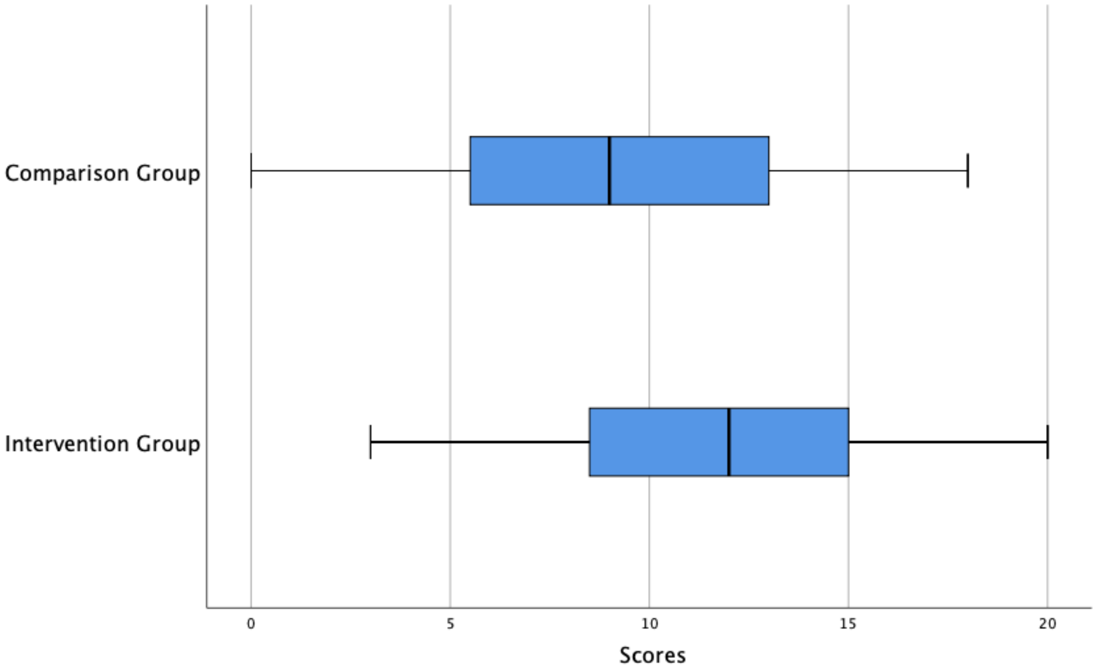


Figure 4.1.2 Double Boxplots Showing the of Results of the Post-Test (Test 1) for the Intervention and Comparison Grade 1 Groups for the Grade 1 Participants

Table 4.1.1 shows the results of the Chi-Squared Test for the grade 1 participants. The results of the Pearson's Chi-Squared Test scores for the association between progress scores and groups was 30.09 with 3 degrees of freedom, which is statistically significant at the 0.05 level.

			Group
GRADE 1	PROGRESS	Chi-square	30.087
		Df	3
		Sig	.000

Table 4.1.1 Pearson Chi-Square Tests Showing the Association Between Progress Scores and the Groups for the Grade 1 Participants

Table 4.1.2 reveals that the mean difference between the pre- and post-tests for the comparison group is 0.18 with a standard deviation of 2.63 and effect size of 0.068. As summarized in Table 4.1.2, the mean difference between the pre- and post-tests for the intervention group is 2.83, standard deviation is 2.67 and the effect size is 1.06. Based on Cohen's d convention, the effect size for the comparison group is small, since 0.068 < 0.2 and, effectively, zero whereas the effect size for the intervention group is large, since 1.06 > 0.8. Hattie's (2009) synthesis of meta-analysis of interventions in the field of education found that the average overall effect size, using Cohen's d statistic was 0.4. Therefore, an effect size of 1.06 is well above average and can be considered to indicate a very substantial positive impact of the MEP intervention

Groups	Mean Difference	Std. Deviation	Effect Size
Comparison Group	0.18	2.63	0.068
Intervention Group	2.83	2.67	1.06

Table 4.1.2 Cohen's d Effect Size of the Pre- and Post-tests for Each Grade 1 Group.

The results of the ANCOVA [F(1, 286) = 119.3, p = .000] indicated a significant difference in post-test scores between the two groups after adjusting for the pre-test scores. The participants in the intervention group obtained higher scores on the post-test than those in the comparison group, with an effect size reported η^2 =.294. Since Montgomery (2012) has stated that the eta squared effect size cut off points are small = 0.01, medium = 0.06 and large = 0.14, an effect size of η^2 =.294 indicates a large effect size. The adjusted marginal mean post-test scores are displayed in Table 4.1.3. Covariates appearing in the model are evaluated at the following values: Pre-test = 4.6332.

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Comparison Group	4.819	.196	4.434	5.204
Intervention Group	7.461	.142	7.181	7.741

Table 4.1.3 Adjusted Mean Post-test Scores (Grade 1)

4.1.2 Results from the Grade 2 Participants

Figure 4.1.3 shows that for the pre-test (test1) for the grade 2 participants, the intervention group had a median score of 9 and the comparison group has a median score of 8. This is an indicator that for the pre-test, the median score of the intervention group is greater than the median score of the comparison group. The range of scores for the intervention group is 17 (that is from 2 to 19) and the interquartile range is 5 while the range of scores for the comparison group is 16 (that is from 2 to 18) the interquartile range is 5. That is the pre-test score variability of the intervention group is greater than that of the comparison group. For the intervention group, the lower 25% of the scores lies between 1 and 7, the middle 50% of the test scores of the lies between 7 and 12 the upper 25% of scores lies between 12 and 19. For the comparison group the lower 25% of the scores lies between 1 and 6, the middle 50% of the test scores of the lies between 6 and 11 the upper 25% of scores lies between 11 and 18. The prior attainment of the both the intervention and comparison groups is very similar although the intervention group had slightly higher scores.

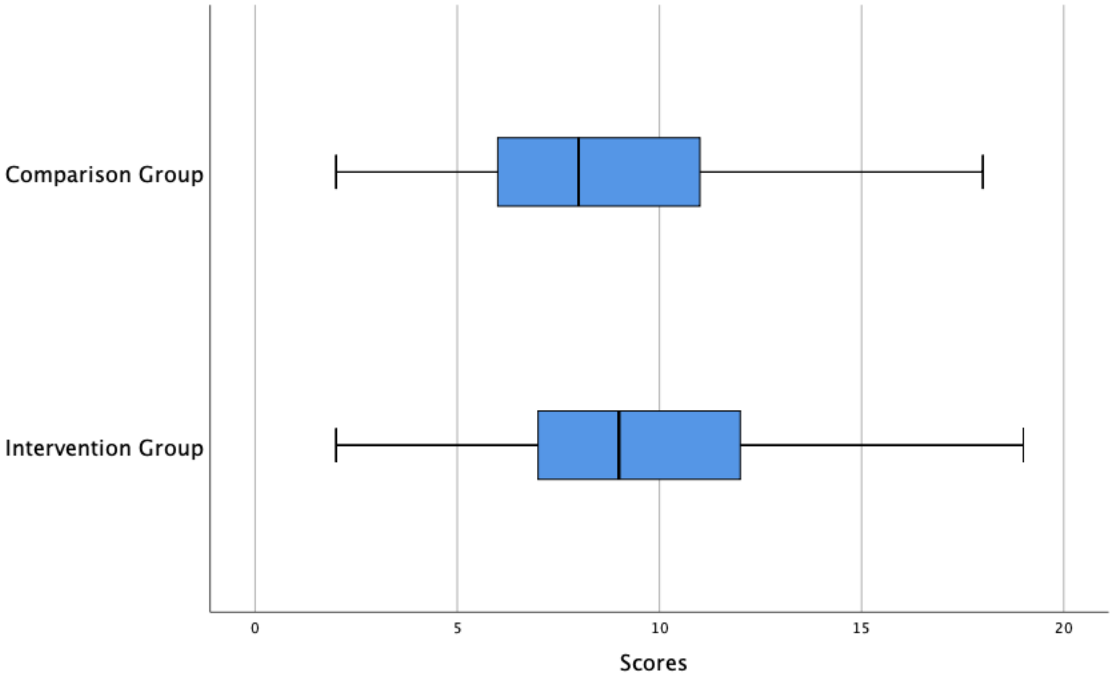


Figure 4.1.3 Double Boxplots Showing the Results of the Pre-test (test 1) for the Intervention and the Comparison Groups for the Grade 2 participants.

Figure 4.1.4 shows that for the post-test (test 2) for the grade 2 participants, the intervention group had a median score of 24 and the comparison group had a median score of 14. This is an indicator that for the post-test, the median score of the intervention group is greater than the median score of the comparison group. The range of scores for the intervention group is 24 (that is from 12 to 36) and the interquartile range is 7.5 while the range of scores for the comparison group is 30 (that is from 2 to 32) and the interquartile range is 10. That is the post-test score variability of the comparison group is greater than that of the intervention group. For the intervention group, the lower 25% of the scores lies between 11.5 and 19.5, the middle 50% of the test scores of the lies between 19.5 and 27 the upper 25% of scores lies between 27 and 36. For the comparison group the lower 25% of the scores lies between 1.5 and 9, the middle 50% of the test scores of the lies between 9 and 19 the upper 25% of scores lies between 19 and 31.5. The box plots for the post-test results shows a substantial overall increase for the intervention group.

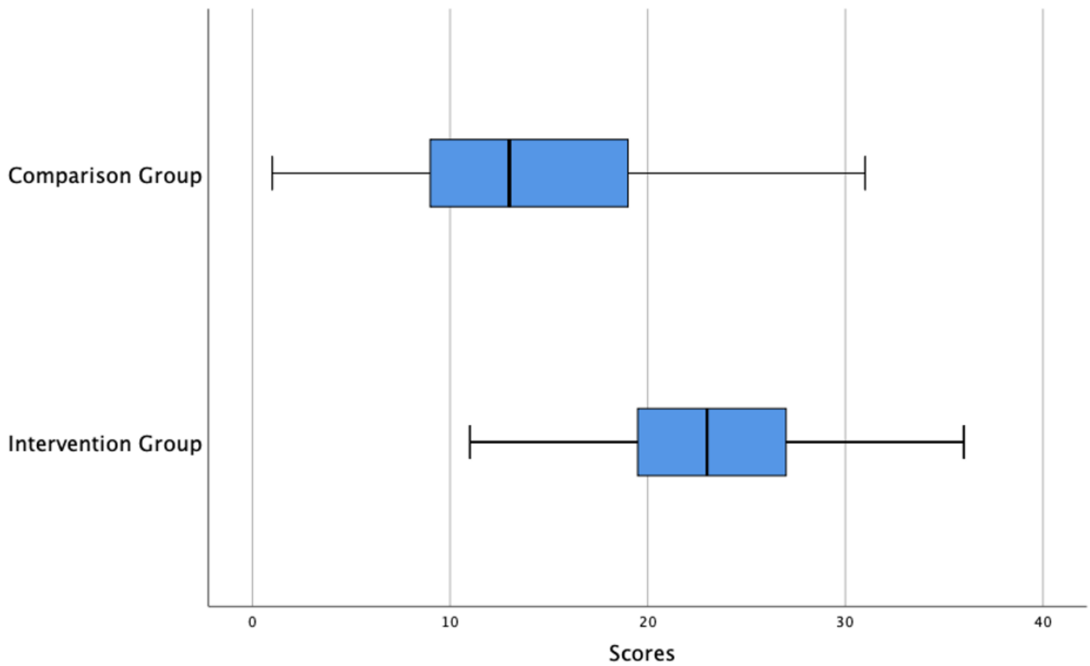


Figure 4.1.4 Double Boxplots Showing the Results of the Post-test (test 2) for the Intervention and the Comparison Groups for the Grade 2 participants.

Table 4.1.4 shows the results of the Chi-Squared Test for the grade 2 participants. The results of the Pearson's Chi-Squared Test scores for the association between progress scores and groups was 58.59 with 3 degree of freedom, which is statistically significant at the 0.001 level. There is very strong evidence of a relationship between the groups and the progress made (Chi-Squared = 58.589, df= 3, p <0.001).

			Group
GRADE 2	PROGRESS	Chi-square	58.589
		Df	3
		Sig	.000

Table 4.1.4 Pearson Chi-Square Tests Showing the Association Between Progress Scores and the Groups for the Grade 2 Participants

Table 4.1.5 reveals that the mean difference between the pre- and post-tests for the comparison group is 0.25 with a standard deviation of 2.46 and effect size of 0.102. As summarized in Table 4.1.5, the mean difference between the pre- and post-tests for the intervention group is 5.54, standard deviation is 5.12 and the effect size is 1.08. Based on Cohen's d convention, the effect size for the comparison group is small, since 0.102< 0.2 and, effectively, zero whereas the effect size for the intervention group is large, since 1.08 > 0.8. Hattie's (2009) synthesis of meta-analysis of interventions in the field of education found that the average overall effect size, using Cohen's d statistic was 0.4. Therefore, an effect size of 1.08 is above average and can be considered to indicate a very substantial impact of the MEP intervention.

Groups	Mean Difference	Std. Deviation	Effect Size
Comparison Group	0.25	2.46	0.102
Intervention Group	5.54	5.12	1.08

Table 4.1.5 Cohen's d Effect Size of the Pre- and Post-tests for Each Grade 2 Group.

The results of the ANCOVA [F(1, 219) = 120.025, p = .000] indicated a significant difference in post-test scores between the two groups after adjusting for the pre-test scores. The participants in the intervention group obtained higher scores on the post-test than those in the comparison group, with an effect size reported ($\eta^2 = .354$). Since Montgomery (2012) has stated that the eta squared effect size cut off points are small = 0.01, medium = 0.06 and large = 0.14, an effect size of $\eta^2 = .354$ indicates a large effect size. The adjusted marginal mean post-test scores are displayed in Table

4.1.6. Covariates appearing in the model are evaluated at the following values: Pre-test = 8.7162.

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Comparison Group	8.773	.408	7.969	9.578
Intervention Group	14.367	.306	13.764	14.971

Table 4.1.6 Adjusted Mean Post-test Scores (Grade 2)

4.2 THE IMPACT OF THE MEP ON STUDENTS' ATTITUDE AND DISPOSITION TOWARDS MATHEMATICS

The second research question was aimed at examining how the implementation of the MEP impacted students' attitude and disposition towards mathematics. To answer this question, the results from the pre- and post-children's mathematics attitudinal surveys and the focus group interviews were analysed. The specific scale that applied to the attitudinal survey is: 1—no, 2—unsure and 3—yes. Tables 4.2.1 and 4.2.2 shows the results of the pre- and post-children's mathematics attitudinal surveys for the grade 1 students.

	Pre-Attitudinal Survey (%)			Post-Attitudinal Survey (%)		
	Yes	Unsure	No	Yes	Unsure	No
I like mathematics	46	6	48	60	5	35
I can learn mathematics	47	9	44	55	7	38
I like going to mathematics classes	44	6	50	59	3	38
Mathematics is interesting	41	15	44	51	11	38
My teacher makes mathematics fun	38	15	47	53	5	42
I enjoy doing mathematics	46	7	47	55	5	40
I do well in mathematics	39	18	43	48	11	41
Mathematics is hard for me	49	7	44	39	6	55
I will use mathematics in the future	58	9	33	62	7	31
Mathematics is important to my everyday life	48	5	47	55	3	42

Table 4.2.1 Pre- and Post-Children's Mathematics Attitudinal Survey for the Intervention Group for the Grade 1 Participants

	Pre-Attitudinal Survey (%)			Post-Attitudinal Survey (%)		
	Yes	Unsure	No	Yes	Unsure	No
I like mathematics	44	9	47	47	7	46
I can learn mathematics	43	12	45	47	9	44
I like going to mathematics classes	43	6	51	45	6	49
Mathematics is interesting	40	7	53	40	7	53
My teacher makes mathematics fun	45	6	49	49	4	47
I enjoy doing mathematics	39	11	50	42	9	49
I do well in mathematics	41	6	53	43	5	52
Mathematics is hard for me	54	5	41	50	4	46
I will use mathematics in the future	51	6	43	52	5	43
Mathematics is important to my everyday life	49	6	45	52	5	43

Table 4.2.2 Pre- and Post-children's Mathematics Attitudinal Survey for the Comparison Group for the Grade 1 Participants

The tables revealed that after the intervention, there was a significantly positive change in how students from the intervention group viewed mathematics. Higher percentage increases were observed in students' responses on items from the survey that addressed positive feelings towards mathematics in the intervention group. The data showed that for the intervention group 14% more of the students indicated that they liked mathematics and 10% more students thought that mathematics was interesting on the post children's mathematics attitudinal surveys. For the comparison group it was noted that 3% more of the students indicated they liked mathematics and there were no changes in the number of students who indicated that mathematics was interesting on the post-children's mathematics attitudinal survey. It was also noted that 10% less of the students in the intervention group found mathematics hard on the post-children's mathematics attitudinal survey, while 4% less of the students in the comparison group found mathematics hard on the post-children's mathematics attitudinal survey.

The data also disclosed that on issues related to the teaching and learning of mathematics, students from the intervention group exhibited greater positive changes when compared to the comparison group. Evidence of this was recorded when 8% more of the students from the intervention group indicated that they could learn mathematics, 15% more stated they like going to mathematics classes, 15% more indicated that their teacher made mathematics fun, 9% more indicated that they enjoyed doing mathematics and 7% more indicated they can do well in mathematics on the post-children's mathematics attitudinal survey. For the comparison group 4% more of the students indicated that they could learn mathematics, 2% more of the students indicated that they liked going to mathematics class, 4% more of the students indicated that their teacher made mathematics fun, 3% more indicated that they enjoy doing mathematics and 2% more indicated that they can do well in mathematics on the post-children's mathematics attitudinal survey.

There was a greater increase in the number of students from the intervention group who viewed mathematics as being important in the real-world context after the intervention. For the intervention group, 4% more of the students indicated that they would use mathematics in the future and 7% more indicated that mathematics is important to their everyday lives on the post-children's mathematics attitudinal survey. For the comparison group 1% more of the students indicated that they would use mathematics in the future and 3% more indicated that mathematics is important to their everyday lives on the post-children's mathematics attitudinal survey.

Figures 4.2.1, 4.2.2 and 4.2.3 show the results of the probed pre- and post-children's mathematics attitudinal survey items (items 1, 3 and 8) for the grade 1 students. The figures give a visual display of the differences recorded in students' responses by groups. The data showed that after the intervention, there was a significant positive change in how students from the intervention group viewed mathematics.

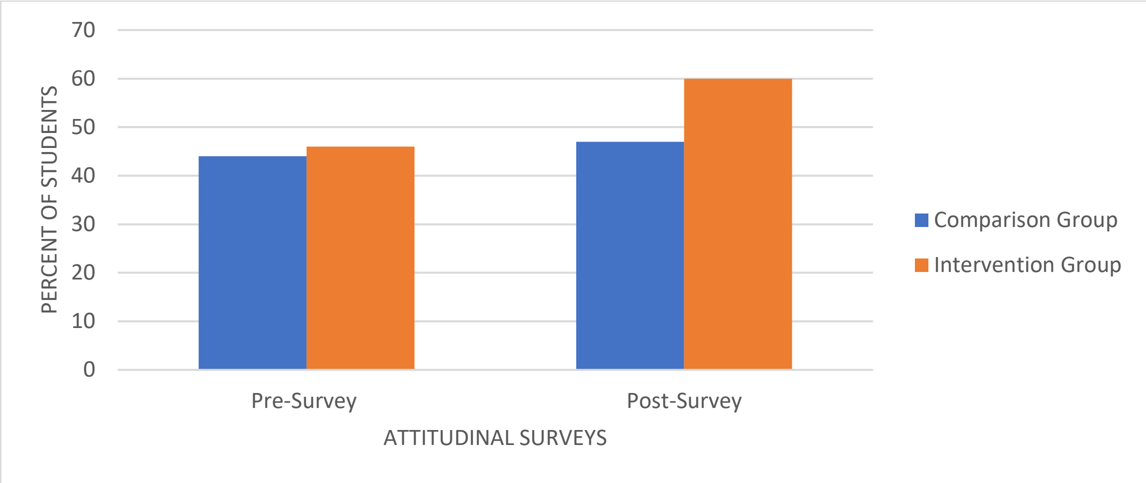


Figure 4.2.1 Comparative Bar Chart Showing the Percent of Grade 1 Students who Indicated that They Liked Mathematics

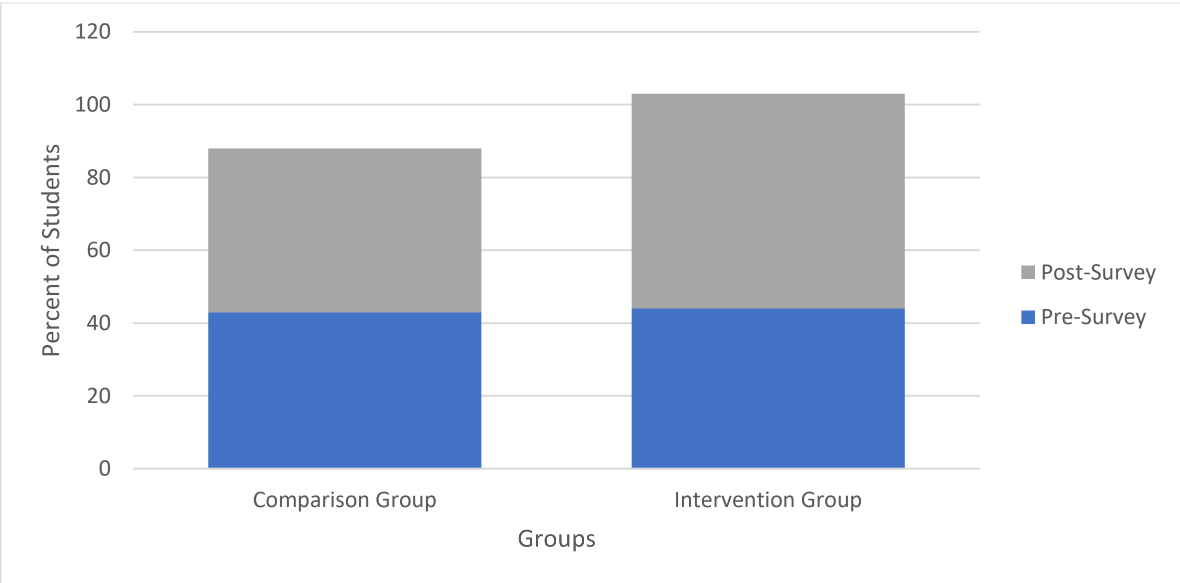


Figure 4.2.2 Segmented Bar Chart Showing the Percent of Grade 1 Students who indicated that They Liked Going to Mathematics Classes

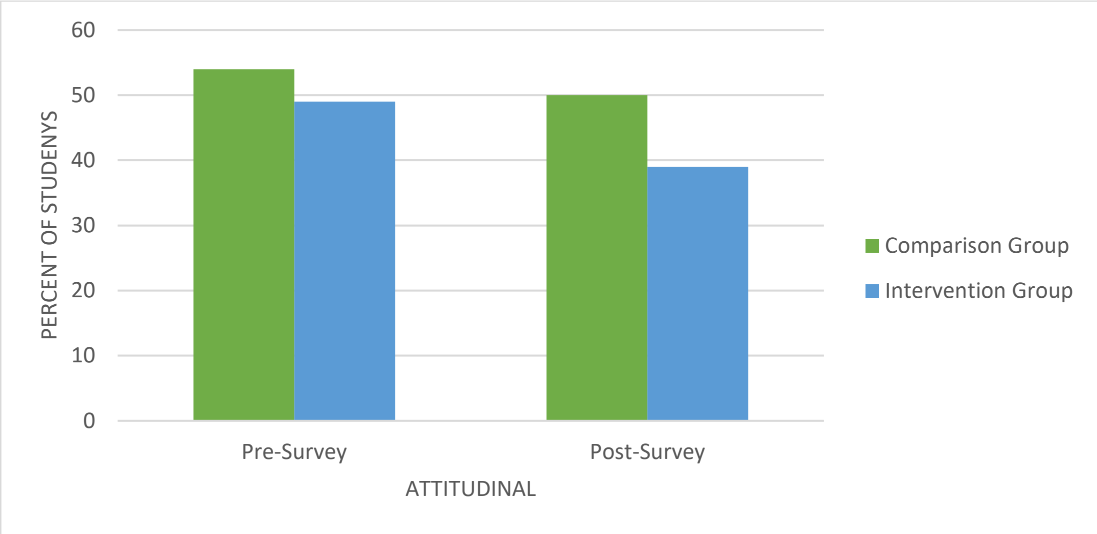


Figure 4.2.3 Comparative Bar Chart Showing the Percent of Grade 1 Students who Indicated that Mathematics was Hard

Tables 4.2.3 and 4.2.4 show the results of the pre- and post-children's mathematics attitudinal surveys for the grade 2 students.

	Pre-Attitudinal Survey (%)			**Post-Attitudinal Survey (%)**		
	Yes	**Unsure**	**No**	**Yes**	**Unsure**	**No**
I like mathematics	47	3	50	56	2	42
I can learn mathematics	44	6	50	57	4	39
I like going to mathematics classes	42	5	53	55	4	41
Mathematics is interesting	44	1	55	57	1	42
My teacher makes mathematics fun	46	6	48	59	5	36
I enjoy doing mathematics	46	3	51	56	2	42
I do well in mathematics	41	8	51	56	6	38
Mathematics is hard for me	57	1	42	44	1	55
I will use mathematics in the future	48	5	47	57	2	41
Mathematics is important to my everyday life	48	4	48	60	1	39

Table 4.2.3 Pre- and Post-children's Mathematics Attitudinal Survey for the Intervention Group for the Grade 2 Students

	Pre-Attitudinal Survey (%)			Post-Attitudinal Survey (%)		
	Yes	Unsure	No	Yes	Unsure	No
I like mathematics	44	9	47	46	8	46
I can learn mathematics	40	13	47	44	11	45
I like going to mathematics classes	39	11	50	41	10	49
Mathematics is interesting	43	9	48	46	9	45
My teacher makes mathematics fun	46	9	45	48	8	44
I enjoy doing mathematics	45	9	46	45	9	46
I do well in mathematics	42	13	45	46	11	43
Mathematics is hard for me	60	4	36	56	3	41
I will use mathematics in the future	58	1	41	60	0	40
Mathematics is important to my everyday life	56	0	44	56	0	44

Table 4.2.4 Pre- and Post-children's Mathematics Attitudinal Survey for the Comparison Group for the Grade 2 Participants

The data shows that after the intervention, there was a significantly positive change in how students from the intervention group viewed mathematics. Higher percentage increases were observed in students' responses on items from the survey that addressed positive feelings towards mathematics in the intervention group. The data showed that for the intervention group 9% more of the students indicated that they liked mathematics and 13% more students thought that mathematics was interesting on the post-children's mathematics attitudinal surveys. For the comparison group it was noted that 2% more of the students indicated they like mathematics and 3% more thought that mathematics was interesting on the post-children's mathematics attitudinal survey. It was also noted that 13% less of the students in the intervention group found mathematics hard on the post-children's mathematics attitudinal survey, while 4% less of the students in the comparison group found mathematics hard on the post-children's mathematics attitudinal survey. The data also disclosed that on issues related to the teaching and learning of mathematics, students from the intervention group exhibited greater positive changes when compared to the comparison group. Evidence of this was noted when 13%

more of the students from the intervention group indicated that they could learn mathematics, 13% more stated they like going to mathematics classes, 13% more indicated that their teacher made mathematics fun, 10% more indicated that they enjoyed doing mathematics and 15% more indicated they can do well in mathematics on the post-children's mathematics attitudinal survey. For the comparison group 4% more of the students indicated that they could learn mathematics, 2% more of the students indicated that they liked going to mathematics class, 2% more of the students indicated that their teacher made mathematics fun, there was no change in the number of students who indicated that they enjoy doing mathematics and 4% more indicated that they can do well in mathematics on the post attitude in a survey.

There was a greater increase in the number of students from the intervention group who viewed mathematics as being important in the real-world context after the intervention. For the intervention group, 9% more of the students indicated that they would use mathematics in the future and 12% more indicated that mathematics is important to their everyday lives on the post-children's mathematics attitudinal survey. For the comparison group 2% more of the students indicated that they would use mathematics in the future and there was no change in the number of students who indicated that mathematics is important to their everyday lives on the post-children's mathematics attitudinal survey.

Figures 4.2.4, 4.2.5 and 4.2.6 show the results of the probed pre- and post-children's mathematics attitudinal survey items (items 1, 3 and 8) for the grade 2 students. The figures give a visual display of the differences recorded in students' responses by groups. The data showed that after the intervention, there was a significant positive change in how students from the intervention group viewed mathematics.

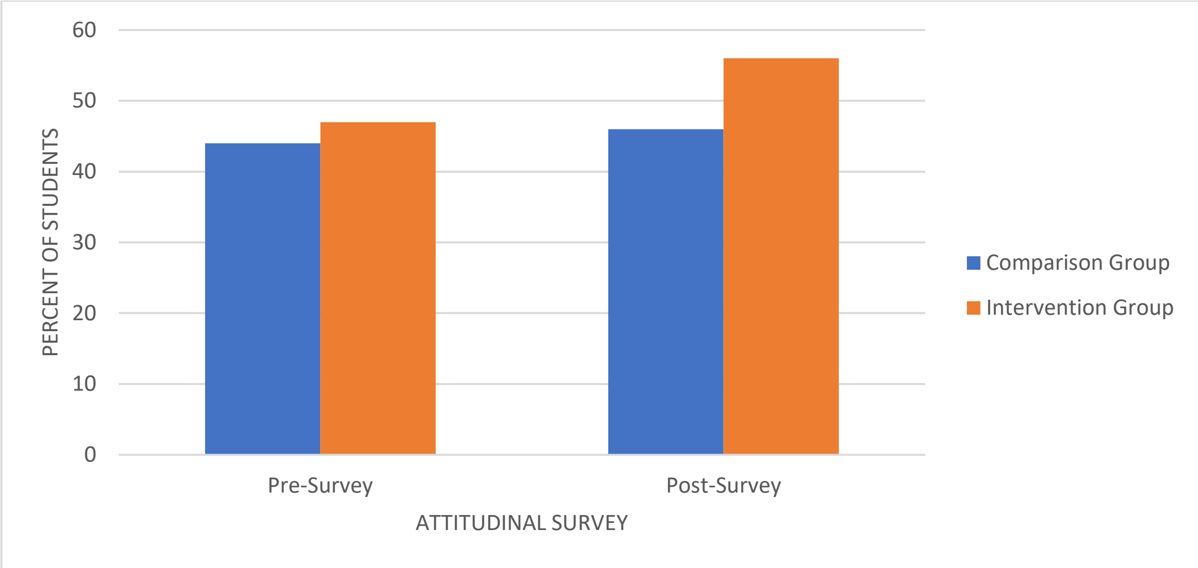


Figure 4.2.4 Comparative Bar Chart Showing the Percent of Grade 2 Students who Indicated that They Liked Mathematics

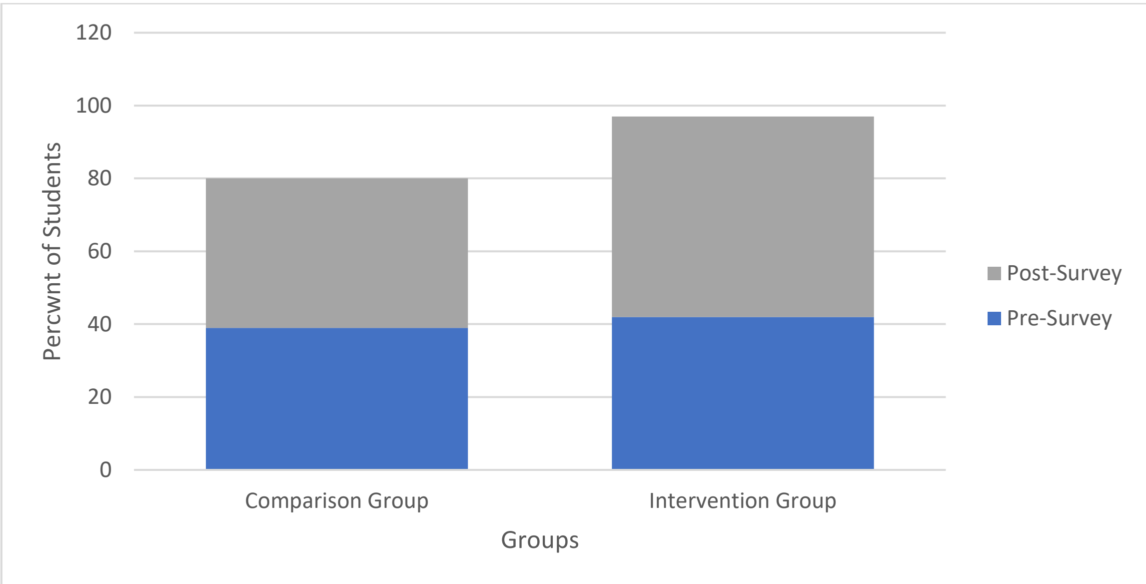


Figure 4.2.5 Segmented Bar Chart Showing the Percent of Grade 2 Students who Indicated that They Liked Going to Mathematics Classes

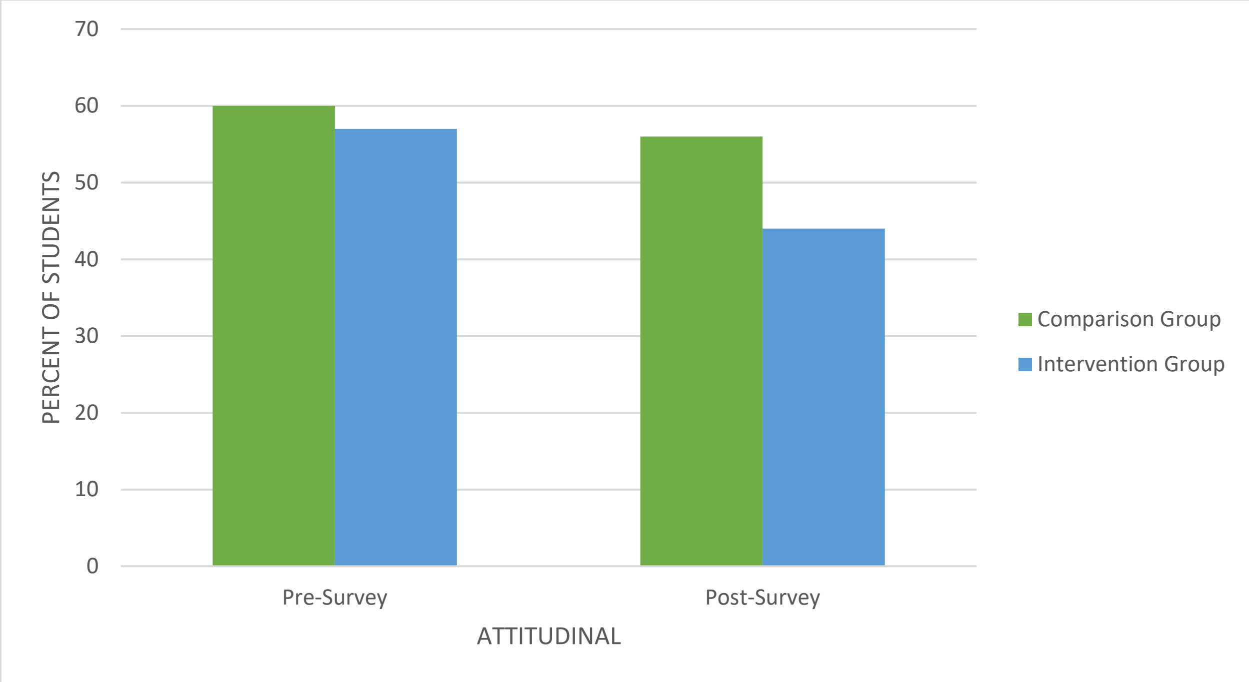


Figure 4.2.6 Comparative Bar Chart Showing the Percent of Grade 2 Students who Indicated that Mathematics was Hard

To develop a deeper understanding of students' reason for selecting their responses, items 1, 3 and 8 of the children's mathematics attitudinal survey were probed. The findings from the probe indicated that prior to the intervention more students indicated that they did not like mathematics because it was challenging. This was supported by the testimonials of students who posited 'it is hard', 'it is difficult to understand', 'it is hard for me to understand', 'mathematics is complicated', 'no one in my family likes mathematics' as reasons they gave for not liking mathematics. Before the implementation of the MEP, it was also found that there were a few students who indicated that they liked mathematics because they thought it was easy. It was however found that after the implementation of the MEP, there was a major increase in the number of students who expressed that they liked mathematics. The data showed that after the intervention more students viewed mathematics as enjoyable and relevant. Evidence of this was noted when students stated that they liked mathematics because 'it is fun', 'it is easy', 'my teacher makes it fun', 'I like to add and subtract', 'I use it at the shop to add' and 'it is fun to do'. Also, a small proportion of the students stated that they were uncertain if they liked mathematics after the intervention. Examples of students' reasons for expressing mixed feelings towards mathematics were 'sometimes it is hard' and 'sometimes I can do the math'.

The findings for question 3 of the children's attitudinal survey showed that more students liked attending math classes after the implementation of the MEP. Prior to the intervention, some students expressed that they did not like to attend mathematics classes because they viewed mathematics classes as boring and challenging. After the intervention, students demonstrated an increased interest in attending mathematics classes because they now view mathematics classes as educational, engaging and rewarding. Students outlined that they enjoy going to mathematics class because:

> math class is fun… I learn new math …I love mathematics…. I get to learn new things…I learn new math everyday…Miss gives me a book and I like the work in this book. I can even colour in the book…My teacher makes class fun…I love my teacher… She helps me understand math…I learn things about maths…. Maths is around us…Miss let us watch other boys and girl doing maths in other countries…We sing and dance while doing math.

It was also found that prior to the implementation of the MEP more students found mathematics to be a hard subject. This finding is based on the students view that mathematics is hard to understand and is difficult. After participating in the intervention more students found mathematics as less challenging subject because their understanding of mathematical concepts increased. After the intervention some of the students' reasons for indicating that mathematics was not hard were 'math is easy for me', 'I can do the problems', 'miss helps me understand', 'I can answer the questions', 'I understand math', 'I can do math', 'I get math problems correct', 'miss helps me a lot' and 'I can do math'

To gain greater insights into students' attitude and dispositions towards mathematics after the intervention, focus group interviews were conducted. From the focus group interviews it was found that after the implementation of the MEP, students indicated that they liked mathematics because they found the subject fun, manageable and applicable to their everyday life. This was evident in students stated reasons for liking mathematics, which included ‘my teacher makes it fun’, ‘I like math now, my teacher makes it easy’, ‘it is fun to do’, ‘I can do the work’, ‘I will use math in my daily life - I love to do math problem’ and ‘I use math when I go to buy things’. There were however a few students who expressed mixed feelings towards liking mathematics because for them mathematics was both easy and challenging. To substantiate this claim, students argued that ‘sometimes it is easy and fun, sometimes it is hard’ and ‘I can do math, but some math is hard’. After participating in the MEP, students indicated that they enjoyed going to mathematics classes because their classes were enjoyable and relevant. Students detailed that ‘math class is fun’, ‘miss makes class fun’, ‘my teacher makes learning fun’, and ‘my teacher makes math feel so real’ as reasons they enjoyed going to mathematics classes. There were however a few students who stated that they sometimes liked attending mathematics classes. One of the main reasons for this stance is because the subject was viewed as sometimes challenging. This was evident when students stated that ‘sometimes the work is hard, and I get nervous, but my teacher is fun’ and ‘my teacher is fun but some of the work is hard for me’.

Participating teachers’ approach to teaching was identified by students as what they liked most about their mathematics classes. As outlined by students, during the implementation of the MEP, teachers used a range of resources, teaching aids and strategies when developing mathematics lessons. During the interview, instructional activities, workbooks, math songs, roleplays, teachers being helpful and learning something new everyday were identified as things students liked most about their mathematics classes. As students shared their experiences of the things they liked most about their mathematics classes, they commented that ‘the way teacher help us understand the work’, and the ‘things teacher uses…these really help us’.

From the focus group interviews, it was found that teachers integrated the use of different resources and teaching aids during the implementation of the MEP. Evidence of this was noted when students stated that their teachers used ‘activity books, computer, projectors, videos, number lines, number cards, shape cards, things in the class and workbooks’ when teaching mathematics. Students also shared that the things teachers used to teach mathematics helped to increase their understanding of the mathematical concepts that were developed. This finding is supported by the testimonials of individual students who stated:

> I understand more when I see the work on the computer. The number lines help me to count and add. The number cards and shape cards help me to answer the questions my teacher gives us. The activity books are fun to use to…I understand when Miss uses them…they just help me understand more…they help me to solve problems. They help me to do the work. The work from the workbook is fun to do and I get to understand the math more. Sometimes they make the lesson easier to understand.

4.3 THE TEACHING STRATEGIES USED IN IMPLEMENTING THE MEP INTO MATHEMATICS CLASSES

Research question 3 examined the teaching strategies that can be used to integrate the MEP into mathematics classes. To answer this question, data from the teacher interview and classroom observations were analysed using the NVivo 12. It was found that the MEP was integrated into the Jamaican primary mathematics classes using:

- Classroom discussion strategies
- Cooperative learning strategies
- Technology based strategies
- Modelling

It was also found that different sub-categories of these four primary teaching strategies were employed in the different intervention classes.

Figure 4.3.1 gives a pictorial representation of the main teaching strategies and sub-categories employed by teachers to integrate the MEP into their mathematics classes.

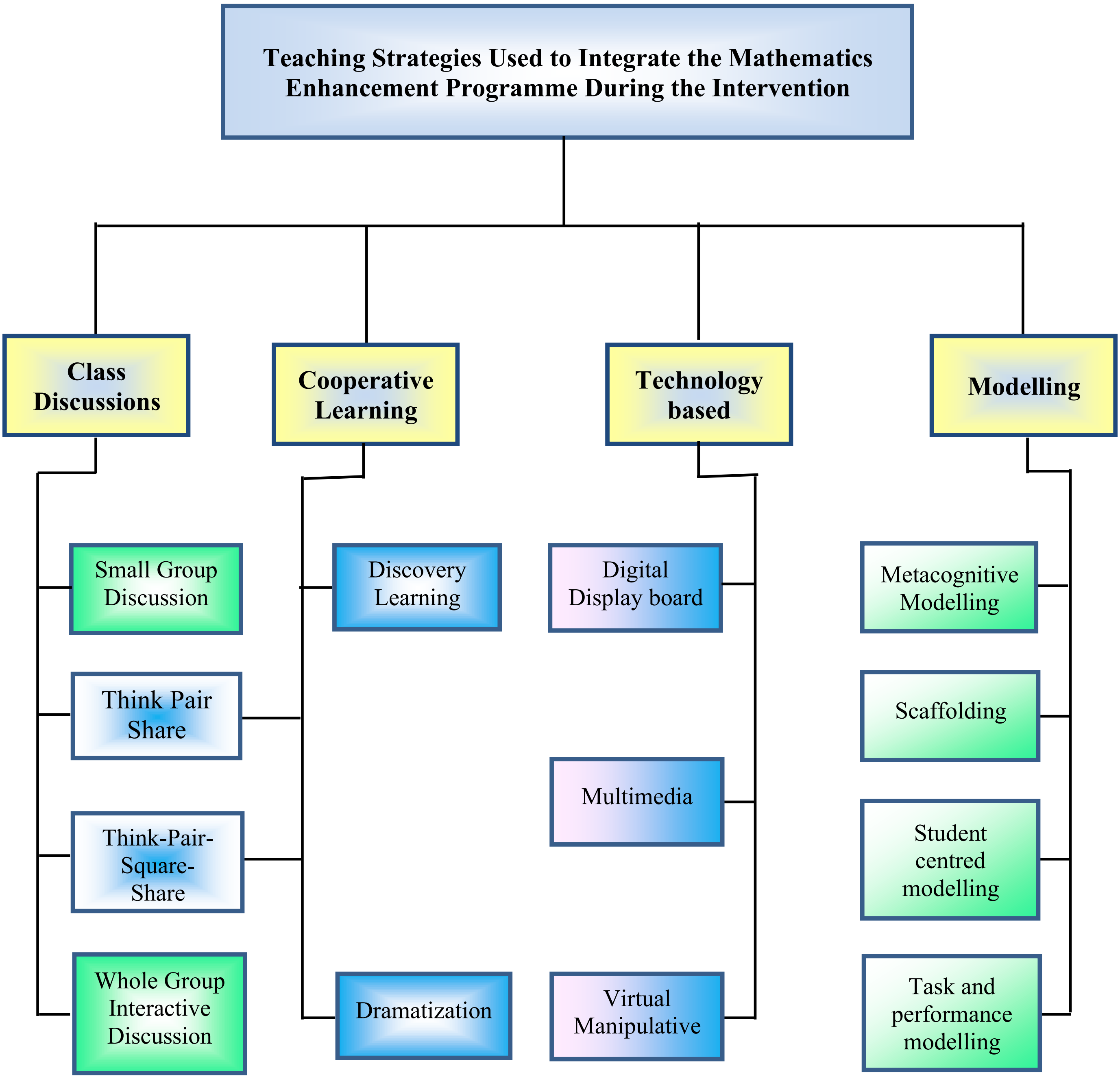


Figure 4.3. 1 Teaching Strategies Used to Integrate the MEP During the Intervention

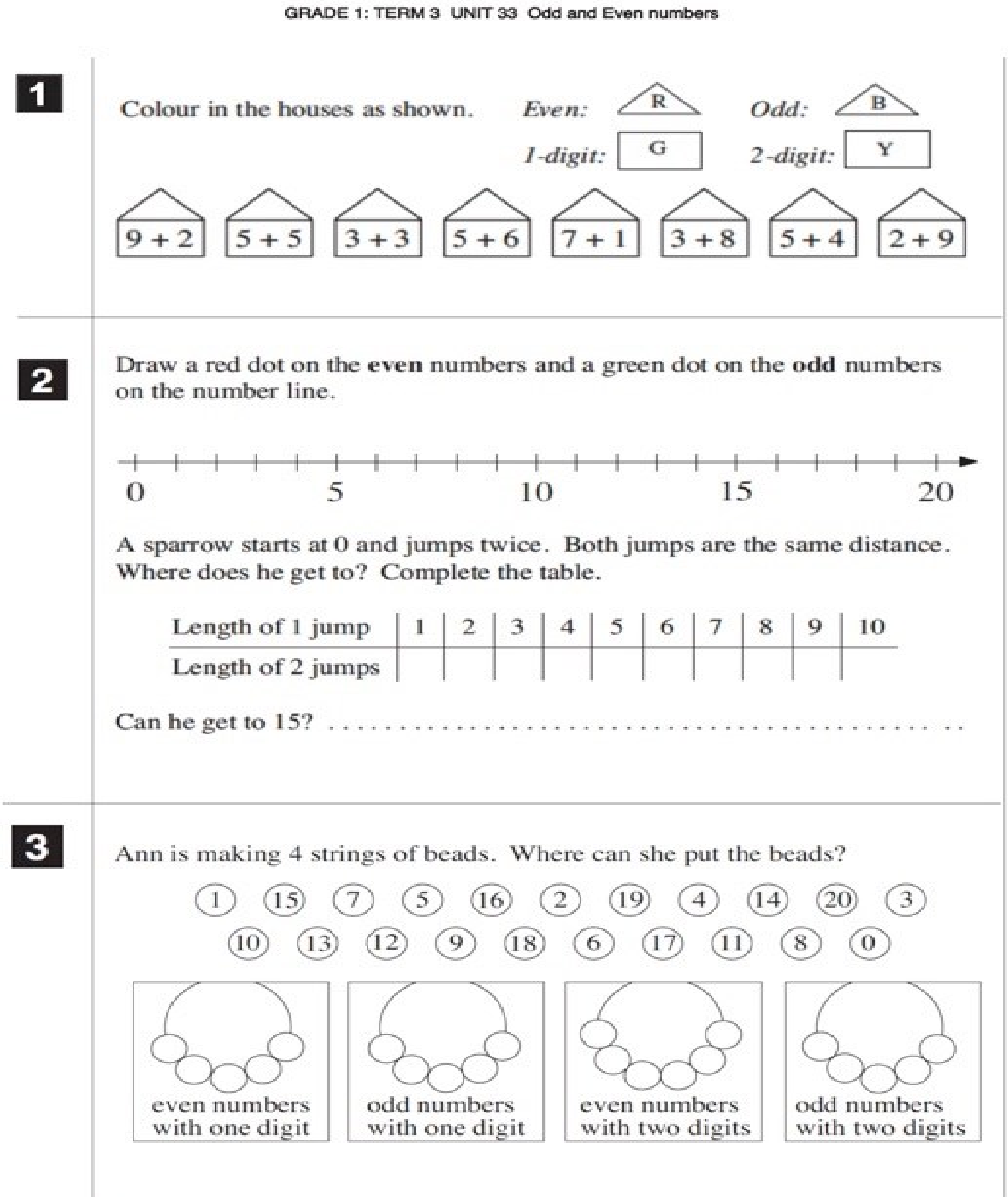
In addition to the teaching strategies that were employed during the integration, it was found that the participating teachers used different supporting resources during the teaching and learning discourse. The supporting resources used during the integration of the MEP are summarized in Table 4.3.1

Supporting Resources	Sub-Categories
MEP resources	Number lines Number gird Rulers
Tangible resources	Manipulative Models
Visual aids	Charts Pictures Graphic organizers

Table 4.3.1 Supporting Resources used During the Integration of the MEP

Classroom observations during the intervention provided evidence of the different teaching strategies that participating teachers employed while integrating the MEP into their classrooms. It was observed that different teachers employed different teaching strategies based on their unique teaching style and the learning needs of their students. Examples of how each of the four teaching strategies were employed are captured in the lesson extracts from the classroom observations presented below.

An example of how teacher CK used the technology-based teaching and the class discussion strategies to introduce the MEP lesson on ‘Odd and Even numbers’ (see figure 4.3.2) is demonstrated below. Additionally, visual aids were a supporting resource used in teacher CK’s lesson. The extract from this lesson is recorded in table 4.3.2.



GRADE 1: TERM 3 UNIT 33 Odd and Even numbers

1

Colour in the houses as shown. *Even:* R *Odd:* B

1-digit: G *2-digit:* Y

9 + 2 | 5 + 5 | 3 + 3 | 5 + 6 | 7 + 1 | 3 + 8 | 5 + 4 | 2 + 9

2

Draw a red dot on the **even** numbers and a green dot on the **odd** numbers on the number line.

0 5 10 15 20

A sparrow starts at 0 and jumps twice. Both jumps are the same distance. Where does he get to? Complete the table.

Length of 1 jump	1	2	3	4	5	6	7	8	9	10
Length of 2 jumps										

Can he get to 15? . . . .

3

Ann is making 4 strings of beads. Where can she put the beads?

1 15 7 5 16 2 19 4 14 20 3

10 13 12 9 18 6 17 11 8 0

even numbers with one digit | odd numbers with one digit | even numbers with two digits | odd numbers with two digits

Figure 4.3.2 Odd and Even Numbers. From the Mathematics Enhancement Programme Jamaica Primary Resources. Grade 1 Term 3. P. 12 (CIMT, 2018)

Teacher CK uses a video that explains the difference between odd and even numbers. This video presentation was followed by a guided discussion as outlined belowed:

Teacher CK: What did you learn from the video?
Students raised hands
Teacher identified students S and T
Student S: even number is like counting by 2 and odd number is every number that cannot be grouped by two.
Students T: even numbers can be divided into two equal groups and odd numbers cannot.

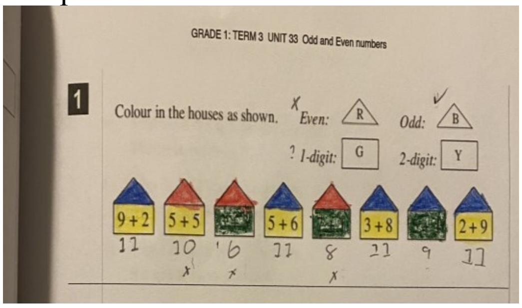
Teacher applauded students for their responses. A whole class interactive discussion supported by visuals then followed to concretize the concepts 'odd and even numbers'.

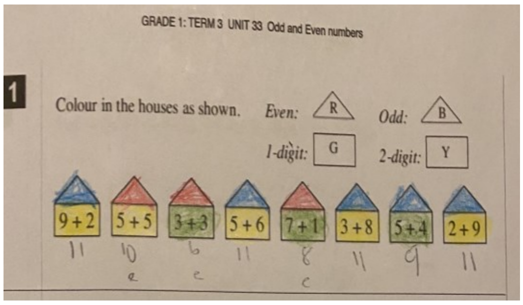
The instruction from activity one of figure 4.3.2 was read, and students were allowed to state what they think they were required to do.

Teacher CK then engaged the class in further whole-class interactive teaching where students were asked to carefully examine the first two questions, discuss with their partner how they would colour the houses and why. Different pair groups shared and explained their answers. Other members of the class were given the opportunity to

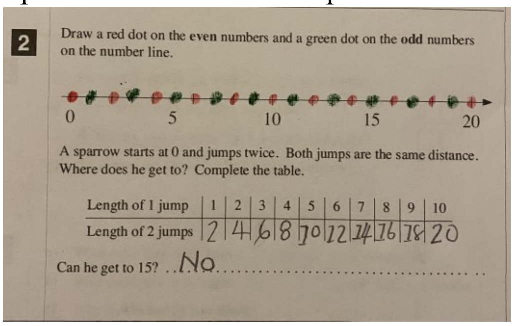
Table 4.3.2 Extract from Teacher CK's Lesson that employed Technology-based and Class Discussion Strategies to Teach the MEP Lesson 'Odd and Even numbers'.

Samples of students work:





Samples from the other components of the lesson:



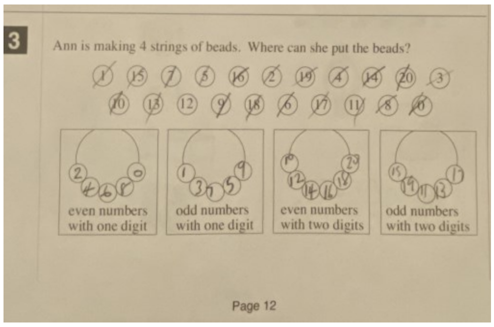


Table 4.3.3 Sample of Students' Work from Teacher CK's Lesson on Odd and Even Numbers

An example of how teacher MD uses modelling and tangible resources to teach number facts and counting (see figure 4.3.3) is demonstrated below. Table 4.3.4 presents an extract from teacher MD's lesson.

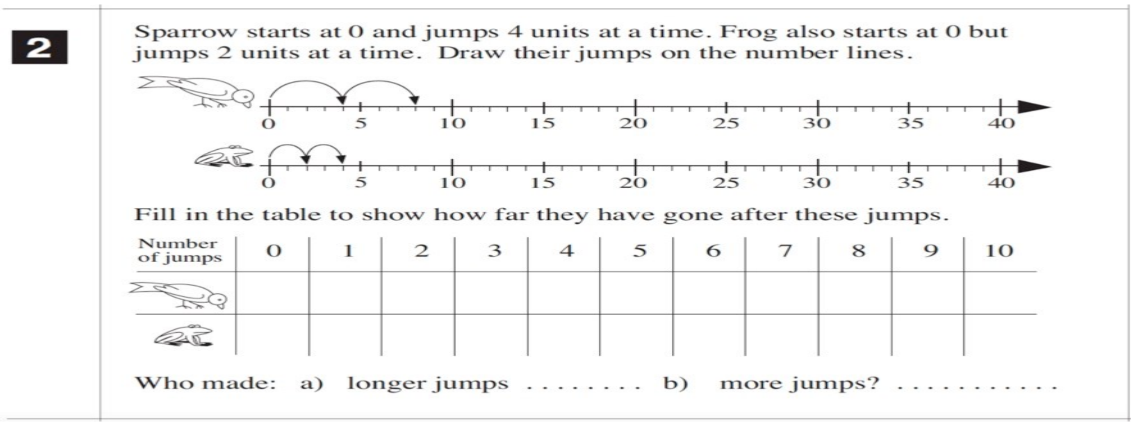


Figure 4.3.3 Number Facts and Counting. From the Mathematics Enhancement Programme Jamaica Primary Resources: Grade 2 Term 3 Unit 22 p. 8 (CIMT, 2018)

Teacher MD introduces activity to students. Teacher focuses on the activity with the sparrow and explains the first two jumps made by the sparrow. The teacher then projected a number line like the one that was used for the question with the sparrow. She then places a picture of a sparrow at zero and then modelled how the sparrow was moving by 4 for the first two jumps.

With the use of whole class interactive discussion, students were asked to share where the sparrow's third and fourth jumps would fall on the number line. Teacher models the jumps as students share their responses.

Student A: 'The third jump would fall on 12 because we are counting by 4 miss'
Teacher MD: Good Job!
Student Y: 'The fourth Jump would land on 16 miss'
Teacher MD: Excellent work!

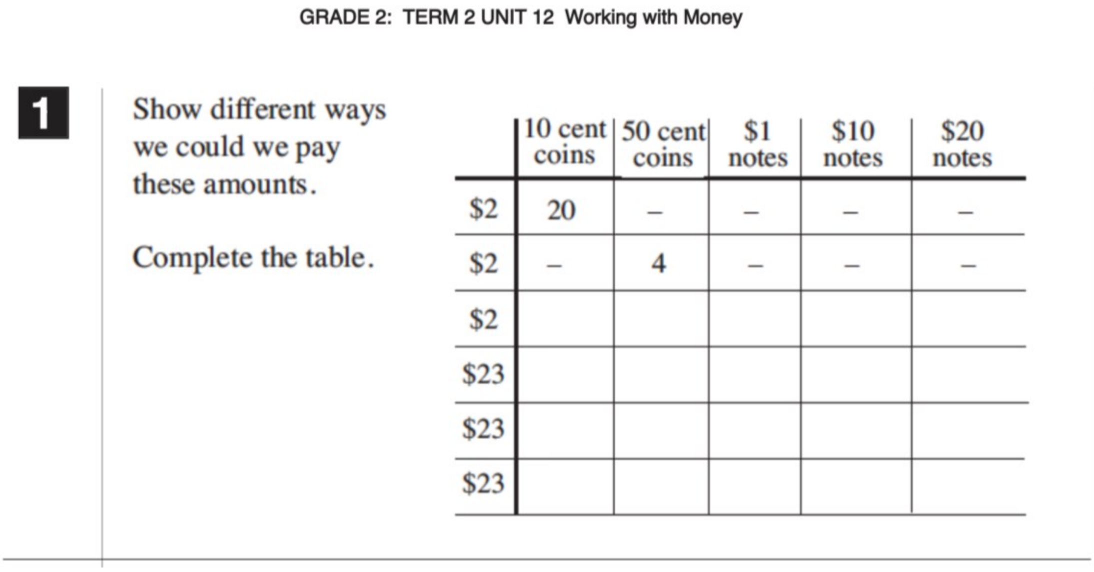
Volunteers were then invited to model for their peers where the 5th and six jumps would fall.

Student M: 'Teacher, jump 5 will be at 20'
Teacher MD: Good job M
Student T: 'Miss, jump six will fall at 24'
Teacher MD: Very good T

Students were then instructed to complete the first row of the table given.
Teacher MD: Using your numbers lines and string, please model the jumps of the frog.
Teacher MD observes students modelling the jumps of the frog.
Teacher MD: Excellent work!
Teacher MD asks for volunteers to model the jumps of the frog on the board. Through interactive whole class discussion, students' responses were discussed.

Table 4.3.4 Extract from Teacher MD's Lesson that uses Modelling and Tangible Resources to Teach the MEP Lesson 'Number Facts and Counting'

Working with Money (see figure 4.3.4) is demonstrated below. Table 4.3.5 presents an extract from teacher MW's class



GRADE 2: TERM 2 UNIT 12 Working with Money

1 Show different ways we could we pay these amounts.

Complete the table.

	10 cent coins	50 cent coins	$1 notes	$10 notes	$20 notes
$2	20	–	–	–	–
$2	–	4	–	–	–
$2					
$23					
$23					
$23					

Figure 4.3.4 Working with Money. From the Mathematics Enhancement Programme Jamaica Primary Resources: Grade 2 Term 2 Unit 12 p. 3 (CIMT, 2018)

Jane: ‘Hey Mary, I want to buy a candy that cost $2.’

Mary: ‘I would love to buy a candy too, but I do not have a $2 note. All I have are 10 cent coins, 50 cent coins and $1 notes.’

Jane: ‘Let me see! Let me see! – Mary, remember is it 100 cents that gives you one dollar. I am sure you can find $2 out of your money’

Mary: ‘Really Jane!’
Jane: ‘Yes Mary! Look, you have 20 ‘10 cent’ coins. Let me do this math….mmmmhhhh. Jane, this is 200 cents. It is the same as $2. You can buy a candy.’

Mary: ‘Wow Jane, you really learning in Ms. MW’s Class. Look Jane I have 4 – 50 cent coins, help me with this math.’

Jane: ‘50 x 4 = 200. This also 200 cents.’

Mary: ‘Which means I have another $2!’

Jane: ‘Yes Mary!’

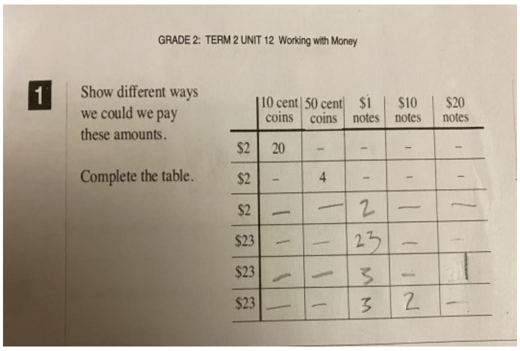
Mary: ‘I can do this one, I have 2 $1 notes, this is another $2. Looks like I can buy 3 candies after all. I will definitely give you one of mine Jane so that we can both have two candies each.’

Jane: ‘Thank you’

Class applauded the students.
The teacher then engaged the class in a whole class interactive discussion where the concepts of converting unit dollars to cents and tens dollars to units or units and tens were established.

Teacher MW then employed the think-pair-share technique with her student to discuss the different ways $23 could be paid.

Table 4.3.5 Extract from Teacher MW’s Lesson that uses Dramatization to Introduce a MEP Lesson on ‘Working with Money’

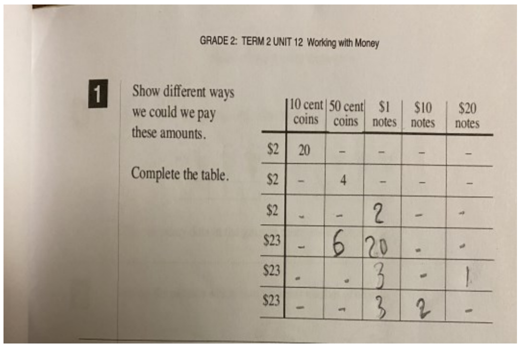


GRADE 2: TERM 2 UNIT 12 Working with Money

1 Show different ways we could we pay these amounts.

Complete the table.

	10 cent coins	50 cent coins	$1 notes	$10 notes	$20 notes
$2	20	–	–	–	–
$2	–	4	–	–	–
$2	–	–	2	–	–
$23	–	–	23	–	–
$23	–	–	3	–	1
$23	–	–	3	2	–



GRADE 2: TERM 2 UNIT 12 Working with Money

1 Show different ways we could we pay these amounts.

Complete the table.

	10 cent coins	50 cent coins	$1 notes	$10 notes	$20 notes
$2	20	–	–	–	–
$2	–	4	–	–	–
$2	-	-	2	-	-
$23	-	6	20	-	-
$23	-	-	3	-	1
$23	-	-	3	2	-

Table 4.3.6 Sample of Students' Responses to the MEP Activity on 'Working with Money'

During the post lesson conference, the teacher stated that she employed the use of dramatization with this class because role playing comes naturally for some of her students, it appeals to the students' interest, arouses their interest, and allows them to see the real-life applicability of the concepts being developed. Teacher MW suggested that '… the use of dramatization allows students to see the real-life applicability of what is being taught… it helps them to appreciate the mathematical concepts more and of course this approach gets the students really excited about the lesson'.

An example of how Teacher JY uses class discussions, technology, and visual aids to teach ‘Measuring time’ (Fig 4.3.5). Table 4.3.7 presents an extract from teacher JY’s lesson.

GRADE 1: TERM 3 UNIT 29 Measuring Time

1

a) How many days are there in February?

b) How many months start with the letter:

J M A O

2

Tom's birthday is on the 7th June. Jane's birthday is on the 10th June.
Jim's birthday is on the 2nd of June.
How many days are there between:

a) Jim's and Tom's birthdays

b) Tom's and Jane's birthdays

c) Jim's and Jane's birthdays?

Figure 4.3.5 Measuring Time. From the Mathematics Enhancement Programme Jamaica Primary Resources: Grade 1 Term 3 P. 2 (CIMT, 2018)

Teacher JY introduces the concept with the use of a video entitle ‘12 months of the year’. This video gave an overview of the different months in the year and the number of days in each month. Teacher JY then led a recap of the video using digital visual aids that showed all the months in the year and the numbers of days in each month. Teacher JY also discussed with students that leap years occur every 4 years because the earth takes about 365 and a quarter of a day to go around the sun. Students were then instructed to turn to page 2 of their MEP Primary, Mathematical Reasoning book. The teacher and the students read the questions. Students were then instructed to: - Write down their answers to question 1 - Discuss their answers with their pair (elbow partner) - Decide on a pair partner to share the group’s answers with the class Selected pair groups were allowed to share their responses. Pair group 1: 28 days are in February Pair group 2: February has 29 days when it is a leap year Teacher JY engaged students in a whole class discussion where students were allowed to agree and disagree with the answers presented by stating a reason for their stance. Selected pair groups were then allowed to share their responses to part b of the question. Pair group 3: 3 months start with letter ‘J’ and 2 months start with the letter ‘M’ Pair group 4: 2 months start with Letter ‘A’ Pair group 5: 1 month start with the letter ‘O’ Teacher applauded and thanked the students for sharing their responses. Whole class interactive discussion of the answers presented then followed. With the use of visual aids, students were instructed to complete question 2 using the think-pair-share method. Below are selected pair group responses to question 2: Group 7: There are 4 days between Jim’s and Tom’s Birthday Group 3: 2 days between Tom’s and Jane’s Birthday Group 8: Miss, there are 7 days between Jim’s and Jane’s birthday. Teacher JY: Excellent work students!

Table 4.3.7 Extract from Teacher JY’s lesson that uses Class Discussions, Technology, and Visual Aids to Teach a MEP Lesson on ‘Measuring time’

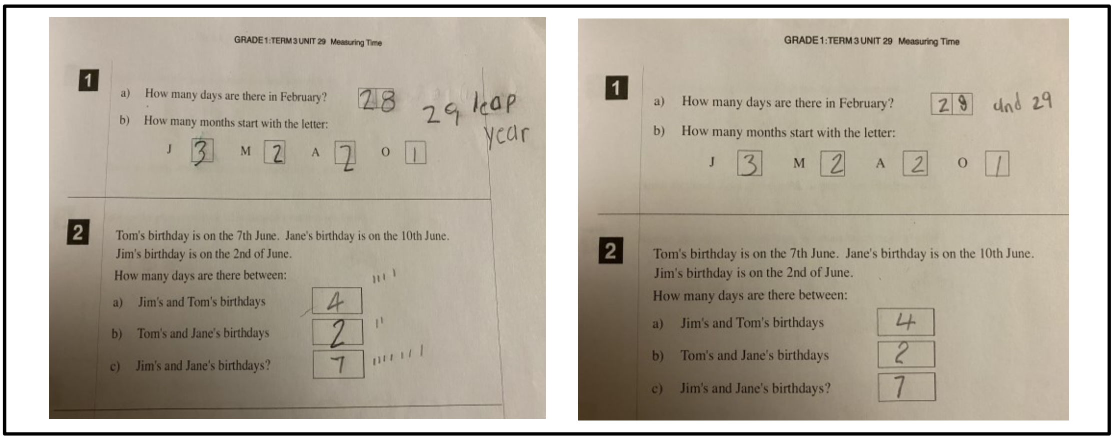


Table 4.3.8 Sample of Students' Work from the Lesson on Measuring Time

Across the intervention classrooms, it was found that the participating teachers used discussions to help students uncover and talk through the mathematical concepts that were developed. Discussions were used to scaffold students' thinking during the content development processes. It was observed that discussions were used to measure students' understanding of the mathematical contents that were developed. The findings from the teacher interviews showed that discussions allowed teachers to gain insight into students thinking and rationale for answers obtained to given problems. As stated by varying participating teachers 'discussions helped me to know what students understood from the lesson', 'it helped me to identify areas [mathematical content] that I needed to expand or re-teach', 'discussions helped me to identify topics that needed remediation' and 'discussions allowed me to identify any misconceptions students may have'. Discussions were also used as a medium for students to collaboratively discuss their views on given topics with their peers. During the classroom observations, students were seen sharing what they knew about topics, establishing the rationale behind their thinking, agreeing, or disagreeing with the views of their peers while giving reasons for their stance. It was also found that teachers used discussions to help students connect concepts to their everyday experiences. Frequent questions that teachers were observed asking, to foster these types of discussions were: How does this [content] apply to your everyday life? Give examples of how this [content] can be used in everyday lives. Do you see things in your classroom that relates to this [content]? and Identify things in your classroom that relates to this [content].

During the intervention, technology was used as a tool to support teaching and learning discourses. Technology was primary used to magnify the MEP lessons through multimedia displays. Through this medium, teachers displayed the MEP materials and systematically guided students through the lessons. Technology was also used to animate parts of the MEP lessons. An example of this was observed when Teacher RS used technology to display an animated video that showed students the relationships between addition and multiplication in an introductory activity (MEP Jamaican Primary Resources, Grade 1: Term 2, Unit 16: Multiplying, p. 7). Participating teachers were also observed using technology to play videos and songs that form introductory activities for MEP lessons. It was also found that teachers used technology to aid in arousing students' interest in the mathematics lessons. Evidence of this was noted in the testimonials of the teachers who opined that technology captured the attention of their students, helped in keeping students quiet and attentive and allowed students to remain focused throughout lessons.

During the intervention, it was found that participating teachers used visual aids to provide students with pictorial representations of the mathematical contents that were developed. Digital visual aids such as videos and multimedia displays and demonstrations, and non-digital visual aids such as poster and anchor charts, graphic organizers and pictures were used during the intervention. It was observed that some of the teachers used visuals to aid with the introduction of MEP lessons. Teachers then guided students into making connections between the pictorial and abstract representations of the content. Evidence of this was observed in teacher JY's class who introduced the MEP adding and subtracting lesson with digital concrete pictorial displays (video) of the concepts associated with addition and subtraction. Teacher JY then systematically guided students into making the connection between the visual display and abstract notations of addition and subtraction. Teachers were also observed introducing and reinforcing lessons with the use of charts that provided pictorial representations of the mathematical contents that were developed. Posters and anchor charts of previously taught lessons were also displayed in the MEP classes. For example, teacher CK was also observed using anchor charts mounted in her class to reinforce the concepts of even and odd numbers. Another form of visual aids that was employed is the use of graphic organizers. Some of the teachers used graphic organizers to help organize and analyse the concepts that were developed. They were also used to help students channel their thoughts by graphically organizing their answers to questions such as what is the question asking me to do?, how do I solve it (given problem)? and how do I know if my answer is correct? Students were also observed referring to their graphic organizers while they participated in discussions related to given problem sets.

During the teacher interview, the participating teachers stated that the methods that they selected to integrate the MEP were dependent upon the learning needs of their students and the resources that they had available to them. Evidence of this is presented is presented below:

Teacher JY: 'I find that think-pair-share discussions were very useful in my MEP lessons. Students shared freely with their pair partner. They seem very comfortable talking to their friends. This I think boasted students' confidence to participate in the whole group discussion which usually follows… I find that students participate more when I use this approach.'

Teacher CK: 'I have used technology and modelling while integrating the MEP into my mathematics classes… I find that when I display the activity that I'm working on, students are more attentive. Modelling helps my students to get a good understanding of what is expected of them, which in turn helps them to effectively complete assigned MEP activities.'

Teacher MD: 'Whole class interactive discussion was a method that I frequently used when integrating the MEP into my mathematics lessons. This helped me to gain insights of the students' thinking or reasoning behind their solutions. As a teacher this helps me to remediate as necessary.'

Teacher CL: 'I have a set of average learners and some of the MEP activities require of the students to be thinking critically. For activities like these, I find that applying scaffolding during the teaching process helps to boast students' understanding of the given problem set which positively impacted their performance on the given tasks.'

Teacher RS: 'I often use video and songs to introduce my MEP lessons… This helped in arousing my students' interest which allowed them to be active participants throughout the lesson.'

The teaching and learning experiences created by the participating teachers during the implementation of the MEP allowed students to connect their cultural experiences to the mathematical concepts being developed. It was observed that the participating teachers modified the MEP lessons to fit students' cultural context while maintaining the deep structures of the MEP. That is, instead of using direct MEP instructions, the participating teachers were open and flexible in incorporating core Jamaican values to shape the social norms of the classroom. Teachers followed the activities in the MEP workbooks and worked relentlessly to keep up with pacing, but they incorporated developmental activities that students could relate to. For example, a grade 2 teacher was observed introducing the lesson 'Using Money' by presenting a scenario of a lady visiting the Kingston Craft Market in Downtown Kingston. Students were shown three indigenous craft items that the lady purchased: a purse made of bamboo that cost $270, a coconut-palm basket that cost $900 and a wooden sculpture that cost $630. Students were then instructed to calculate the cost of:

i. the bamboo purse and the coconut-palm basket

ii. the coconut-palm basket and the wooden sculpture

iii. all three items purchased.

Whole class interactive discussion was then used to develop the concept of spending money. During the discussion the real-life applicability of the concept of using money was further developed and students were asked to share some examples of how they use money in their everyday lives. Following this developmental activity, students completed the 'Using Money' activities from the Grade 2, Term 3, MEP Mathematical Reasoning workbook.

Participating teachers incorporated the use of dramatization, role play and songs in their lessons, activities that mirror the cultural legacy of Jamaica. Some of these activities incorporated the use of items indigenous to Jamaica. For example, one teacher used Jamaican-based farm produce (yam, sweet potato, dasheen) and other indigenous items (Blue Mountain coffee, wood carved sculpture) during a role play, to introduce mass to a grade 2 class. Teachers were also observed creating and introducing students to songs, made to the Jamaican reggae beat, that summarise the key mathematical concepts developed during the implementation of the MEP. It was also observed that through scaffolding, participating teachers often connect the concepts to be developed to students' everyday experiences thus creating linkages that progressed into knowledge development. The MEP materials were also presented in the learners' native language articulations. That is, lessons were delivered using the Jamaican English and in some cases the nations' dialect. It was however observed that the dialect was mostly used in introductory or concept-building activities such as dramatization.

4.4 THE TEACHING STRATEGIES FOUND TO BE MOST EFFECTIVE FOR IMPLEMENTING THE MEP

Research question 4 examined the most effective teaching strategies for integrating the MEP into Jamaican primary classrooms. To answer this question, results from the classroom observations and teacher interviews were analysed using NVivo 12. It was found that the most effective teaching strategies for integrating the MEP are from each of the four main teaching strategies used for integrating the MEP:

- ❖ Classroom Discussion Strategies
- ❖ Cooperative learning Strategies
- ❖ Technology based Strategies
- ❖ Modelling

Table 4.4.1 outlines the specific sub-category of teaching strategies that were identified as the most effective teaching strategies for integrating the MEP.

Teaching Strategies	Sub-Categories
Classroom discussions strategies	Think-pair-share Whole class interactive discussions
Cooperative learning strategies	Think-pair-share
Technology based strategies	Multimedia presentations
Modelling	Scaffolding

Table 4.4.1 Most Effective Teaching Strategies for Integrating the MEP

From Table 4.4.1 it was evident that the specific teaching strategies that were most effective for integrating the MEP are:

- Think-pair-square-share
- Multimedia presentations

- Scaffolding
- Whole class interactive discussions.

During the interviews the participating teachers outlined several reasons why these strategies were considered the most effective for integrating the MEP.

Classroom discussions, particularly think-pair-square-share and whole class interactive discussions were identified by teachers as strategies that aided with the effective integration of the MEP. Teachers posited that discussions were a good way to get an understanding of students' rationale for the answers that they arrived at, to gain insight into how students were reasoning and what they already knew about given topics. It was also stated that discussions aided in helping teachers to decide when remediation and enrichment is necessary for their students. Evidence of this is noted in the participating teachers' reflections:

Teacher SH: 'I think classroom discussions helped me as a teacher to understand how the students are thinking. For me this is power beyond measure as I will know how best to meet my students' needs.'

Teacher SJ: 'Discussions created the avenue for me to understand my students' thought process. While integrating the MEP discussions helped me to know how well students were understanding the material. From this, I was able to tweet my lesson to meet my students' need.'

Teacher JY: 'Think-pair-square-share was a very powerful method that aided with the integration of the MEP. Some of my students were initially shy to speak in the whole class discussions but were very open to discuss their work with their elbow partners. Overtime this boosted their confidence and I found that it subsequently positively impacted how students participated in whole class discussions.'

Teacher MW: 'Whole class interactive discussions is a strategy I found to be effective in integrating the MEP. These discussions allowed my students to be integrally involved in the lessons and it helped me as a teacher to become aware of the concepts that my students were misunderstanding. I also found that students tend to perform better on assigned MEP tasks after the class was engaged in whole class interactive discussions.'

It was also found that the use of discussions during the integration of the MEP helped participating teachers to remediate and provide enrichment activities. As stated by Teacher CK 'From the whole class interactive discussions I was able to see how well my students understood the concepts being taught. This helped me to make important decisions on whether to revisit main ideas presented in the lesson or not.' This view was support by teacher AM who purported that: 'Discussions never lie! Whole class interactive discussions provided insights into how well students were understanding the lesson. This I believe was very helpful as I was made aware of when I needed to re-teach, provide additional instructions or extend given activities.'

The use of technology while integrating the MEP was found to be very useful in helping to arouse students' interest and keeping them engaged throughout the lesson. Participating teachers found that technology in the form of multimedia presentations was very effective for the integration of the MEP. The teachers are also of the opinion that the use of technology aided in increasing students understanding of the concepts being taught. During the interview the teacher CK stated that: 'the use of technology kept my students engaged throughout the MEP lesson. I have used a number of video presentations to introduce MEP lessons… I found that technology positively impacted students' understanding of the math content'.

As stated by teacher MD 'I have used animation for some of the MEP lessons. I remember using it to show students how frogs were jumping by four on a counting activity. This helped me to get students' full attention and it provided the students with a visual presentation of what I was explaining to them. I think that technology was useful in the integration as it helps to build students' understanding of what is being taught through visual displays.'

The following are more testimonial reasons why participating teachers are of the belief that the use technology was effective in integrating the MEP.

Teachers RS: '..technology helped my students to stay focus and provided them with 3-D visual aids which I found to have been useful in helping students' to develop a better understanding of the MEP lessons'.

Teacher AM: 'I have used a range of multimedia presentations during the integration and it really helped to engage my students and has positively impacted their attitudes towards mathematics. Also, it was useful in enhancing students understanding of the MEP math content.'

Teacher JY: 'Technology has been useful in helping my students get a visual idea of the mathematics concepts that were being explained and it boosted their understanding of the MEP math content that was being taught.'

Modelling is another teaching strategy that was found to be effective for integrating the MEP. Participating teachers outlined that the use of modelling when integrating the MEP helped in building students' understanding of the concepts being taught. Scaffolding has been identified as the most effective modelling strategy for integrating the MEP. Participating teachers are of the opinion that scaffolding provided all students in their mixed ability classrooms the opportunity to systematically develop an understanding of the concepts that were being developed in each MEP lesson. It was also found that scaffolding was essential for engaging students in meaningful, interactive, whole class discussions, channelling students through the more challenging MEP activities and for breaking the work into manageable chunks which increases the likelihood of students gaining success. Teacher MD shared that '…for the MEP lesson that were more challenging, I had to provide scaffold for the students, I would start off with model activities that would act as examples, then the students and I would work through whole class interactive discussions to complete similar activities and then individual students would have to complete the MEP assigned activity. This I found to have been instrumental in helping students to better understand the concepts that were being developed.' Teacher SJ supported the views of Teacher MD when she purported that 'Scaffolding made it easier for my students to complete the more challenging MEP activities'. Additionally, teacher ER is of the opinion that 'once students were guided into developing an understanding of the MEP content, they were able to effectively complete the assigned activities'.

4.5 BARRIERS TO INCORPORATING THE MEP RESOURCES AND TEACHING STRATEGIES IN JAMAICAN PRIMARY CLASSROOMS

Research question 5 examined the barriers to integrating the MEP resources and lessons in Jamaican primary mathematics classes. To answer this question, the results from the classroom observations and teacher interviews were analysed using NVivo 12. Figure 4.5.1 shows that there are 5 main barriers to integrating the MEP in Jamaican primary classrooms. These barriers are:

- Classroom amentities and resources
- Challenging MEP content
- Teacher based barriers
- Time consuming
- Technological barriers

Figure 4.5.1 also discloses that three of the main barriers to integrating the MEP were further subcategorizeed.

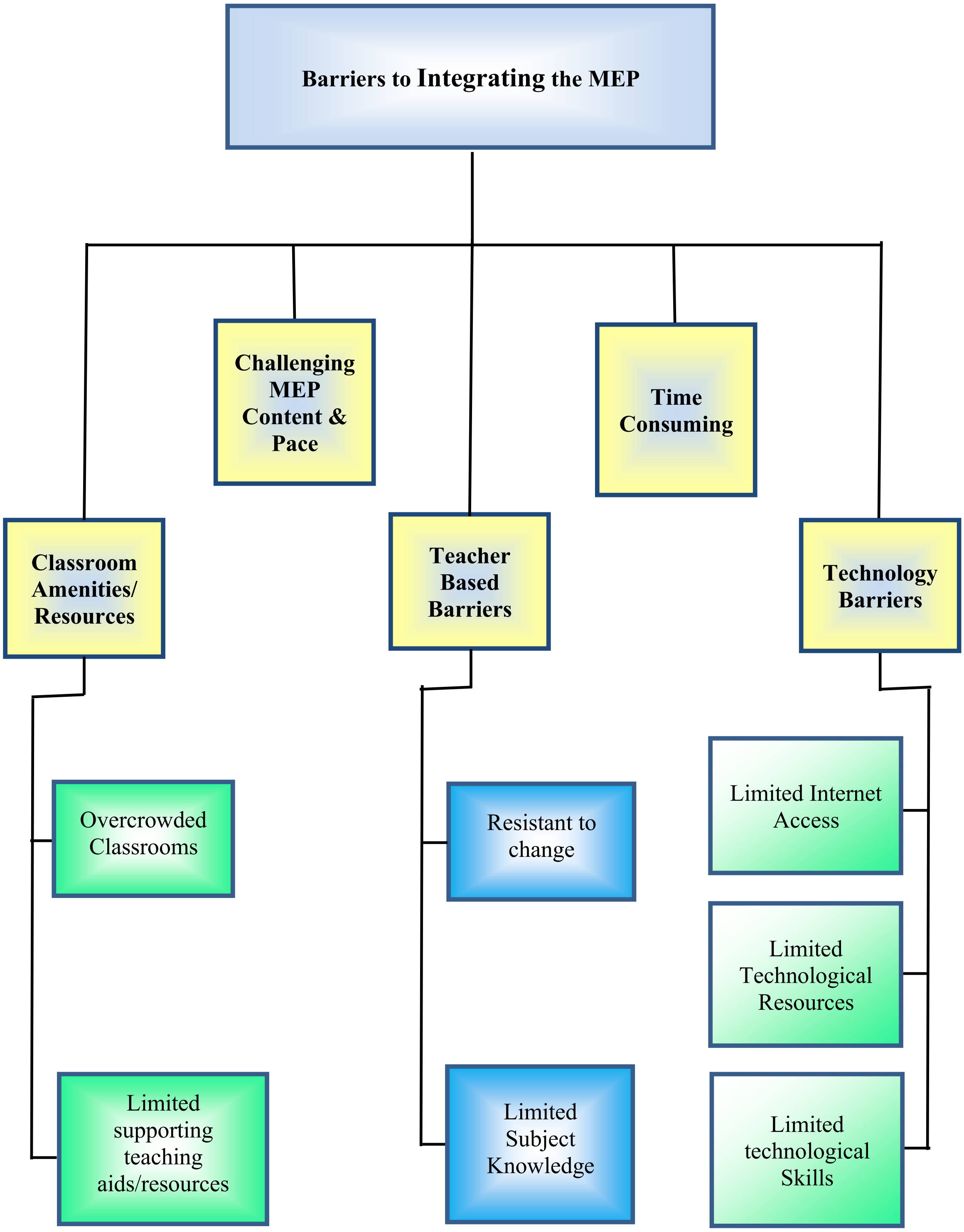


Figure 4.5.1: The Barriers to Incorporating the MEP Resources and Teaching Strategies in Jamaican Primary Mathematics Classes.

The data presented in the Figure 4.5.1 revealed that there are several barriers to integrating the MEP into Jamaican primary mathematics classes. Participating teachers are of the opinion that underdeveloped classroom amenities and limited supporting teacher resources/aids will negatively impact the integration of the MEP into Jamaican primary classrooms. Teachers outlined that overcrowded classrooms will hamper teachers' ability to effectively implement the proposed seating arrangement of the MEP. The evidence of this viewpoint is presented in the teachers' testimonial below:

Teacher ER: 'I have seen classrooms that have as many as 36 students arranged in a very small space…. There is no way for the teacher to have all students comfortable seated and facing the board….it is hard for students to move around in these classroom settings. For classes like these, teachers will struggle to apply the MEP recommended seating.'

Teacher MH: '…because of our limited classroom space, we sometimes have to turn some of the desks and chairs to face each other and the ones in the middle are adjusted to the face the board, this made it hard for us to use the recommended MEP seating arrangements'.

Teacher AM: 'I have had classes that were too small to fit all of my students in a room and students had to physically turn to see the board. It is hard in these situations to ensure that all students are clearly seeing the board when they are seated'.

Teacher SH: 'For me, it is not the class size, it is just that the classroom is too small for my students, this made it hard to effectively follow the recommended seating by the MEP'.

It was found that the limited access Jamaican teachers have to supporting resources and teaching aids will become a problem if the MEP should be fully rolled out in Jamaica. Teacher AM declared that '…we have struggled for years as teachers to get resources for our classes, if this programme is fully implemented in Jamaica and the resources are no longer sponsored then that might be a challenge'. Other proposed impact of having limited access to supporting materials and aids are documented below:

Teacher RS Some of our students cannot afford basic supplies like crayons and pencil, some of the MEP activities required our students to do some form of colouring… when students had to share these resources because of the limited amount that I had available for my class, the required pacing of the MEP was slowed down…I foresee this as a barrier to integrating the MEP especially in the more deprived Jamaican primary schools.

Teacher MD: There were times I needed counters to use alongside the recommended MEP number lines and number squares to ensure that students fully understood certain concepts. I only had limited amount of counters that was sponsored so I had to get creative and made counters out of bottle covers…the truth is, if teachers only have limited resources working with when in cooperating the MEP into their lesson, the true effect of the programme may be compromised.

The data suggested that the challenging MEP content and the required pacing may also be barriers to integrating the MEP. It was outlined that some aspect of the MEP content was challenging for some students and the recommended pacing was sometime too fast depending on the content being taught. It was hard for teachers to keep up with the proposed fast-paced teaching required by the MEP. Declarations by participating teachers outlining the reasons they thought that the challenging content and pacing may become a barrier for integrating the MEP is outlined below:

Teacher MW: '..the content is sometimes hard, the pacing is sometimes hard to keep up with and many other teachers may shy away from using the MEP activities in their mathematics class'.

Teacher CL: ‘I like that the MEP activities ware challenging as it will help to build students critically thinking still but I fear that, for this reason other teachers may not incorporate the use of the MEP resources in their mathematics classes.’

Teacher SH: ‘The MEP activities can be challenging, and sometimes I cannot keep up to the required pacing and this may limit the number of teachers who use the MEP in their classes.’

Teachers’ attitude towards change and their limited subject knowledge were identified as barriers to integrating the MEP. The participating teachers outlined that if teachers were not welcoming of change in their pedagogical practices, then this would be a barrier for integrating the MEP. It was also stated that some teachers would prefer to continue teaching by applying their old teaching methods than to try to learn a new approach to teaching (Teacher ER, AM, CL). Teacher CK, agreeing with this viewpoint, stated that ‘over the years most teachers that I have encountered have not been very open to change and I strongly believe that this is a problem that would negatively affect the integration of the MEP’.

Teacher RS: ‘…teachers who are not open to change will not take the time to learn the feature and structure of the MEP and properly use it in their classes’.

Teacher MD: ‘Some teachers will even outright refuse to try the programme.’

The data suggested that the MEP requires teachers to have a strong mathematical subject knowledge in order to successfully engage students in the MEP teaching and learning discourse. During the interviews, the participating teachers outlined that there are several teachers teaching mathematics who are not trained to teach the subject.

Teacher RS declared 'I was not trained to teach mathematics, but the SKE training that I did before I participated in the MEP is what helped me to successfully incorporate this programme in my class… teachers who have limited math knowledge will struggle with using the MEP resources in their math classes'. This view was supported by teacher MD who opines 'If my content was not good I would have struggled to integrate the MEP into my classroom'. Teacher JY added that 'The MEP is a very good programme but I see teachers who are not trained in mathematics struggling to effectively integrate the MEP in their mathematics classrooms… for the MEP to be rolled out as a national initiative, teacher would need to be trained in mathematics and their content knowledge will need to be optimal'.

Participating teachers have found the MEP to be very time consuming. The data suggested that this barrier would negatively affect the integration of the MEP. Participating teachers' declarations are outlined below:

Teacher JY: 'It is time consuming. As a teacher I have dedicated quality time to ensure that I understand the materials well before I teach my class.'

Teacher ER: 'It takes time to learn and implement the programme.'

Teacher RS: 'I had to spend extra time familiarizing myself with the programme to ensure that I am properly using the resources in my class.'

Teacher CL: 'It takes a long time to prepare for MEP classes….I think teachers who are not welcoming of change will just shy away from the MEP programme because of the time it requires to prepare for these classes.'

Teachers having limited access to technology and minimal technological skills was also identified as another barrier to integrating the MEP. The data showed that participating teachers are of the opinion that technology is integral to the integration of the MEP and if teachers have limited access or is not competent in using technology in the classroom the effect of the MEP on the teaching and learning discourse will be negatively impacted. Teacher RS argued that 'technology is what helped me in preparing for the MEP, there are times I had to do additional research when I am preparing for my MEP classes; Technology was very useful in displaying the assigned MEP activities, doing modelling when necessary and fostering whole class discussions….I think that without technology it would have been harder for me to integrate the MEP into my classes'. Teacher AM added that '… technology makes it easier for facilitating class discussions surrounding assigned MEP activities…I tried discussions without displaying the activities for all to see and it was much easier with technology…schools that have limited access to technology will struggle with this integration'.

Teacher CK shared that 'At times I wanted to show a video and because our school only has one media room that is most times fully booked, I resorted to using my laptop to show videos, I think this is harder for all students to clearly see what is being played on a laptop screen compared to if I had access to a projector where I could display things bigger on my whiteboard'.

Teacher AM added that 'In this era students love to see things in 3D… It arouses their interest, engages them and helps in building students understanding of concepts being taught. I think schools that have limited access to technology will not be able to see the true benefit of implementing the MEP into their mathematics classes'.

It was also found that technology was important in getting teachers prepared for the integration of the MEP. Teachers outlined that they had to be trained in SKE before they could participate in the programme and for some, their training was slowed down because of limited access to technology or not being proficient with using technology. The participating teachers' views are outlined below:

Teacher ER: I have been teaching for years and technology was not so prominent then, I am still learning how to use some features on a computer.

Remember you had to spend extra time teaching me how to access my SKE course…For teachers like me, getting ready to teach the MEP will take a longer time than usual.

Teacher MD: Our school has limited internet access, and this slowed down my SKE training and I had to plan ahead of my lesson and ensure that I downloaded supporting videos as needed to help with building MEP concepts.

Techer SJ: We need technology to be trained to implement the MEP and in some cases we use technology to help with instructions, teachers who do not know how to use technology or do not have access to it will not be able to effectively participate in this programme.

Overall, it was found that teachers believe that if technology access is limited and if teachers struggle to use technology, then there will be limitations to the implementation of the MEP on a wider scale in Jamaica.

4.6. ASPECTS OF THE MEP THAT TEACHERS WOULD ADAPT AND IMPLEMENT IN THEIR OWN PRACTICE

Research question 6 examined which aspects of the MEP participating teachers think they would adapt and implement in their own practice. To answer this question the data obtained from the teachers' interviews were analysed. A pictorial representation of the aspects of the MEP teachers would adapt and implement is summarized in Figure 4.6.1. which shows that participating teachers would adapt and implement the following six MEP aspects.

- Correct use of mathematical notation, layout and language
- MEP Resources (workbooks and supporting materials)
- Seating arrangements

- Spiral curriculum
- Whole class interactive teaching
- Visualizations and manipulatives.

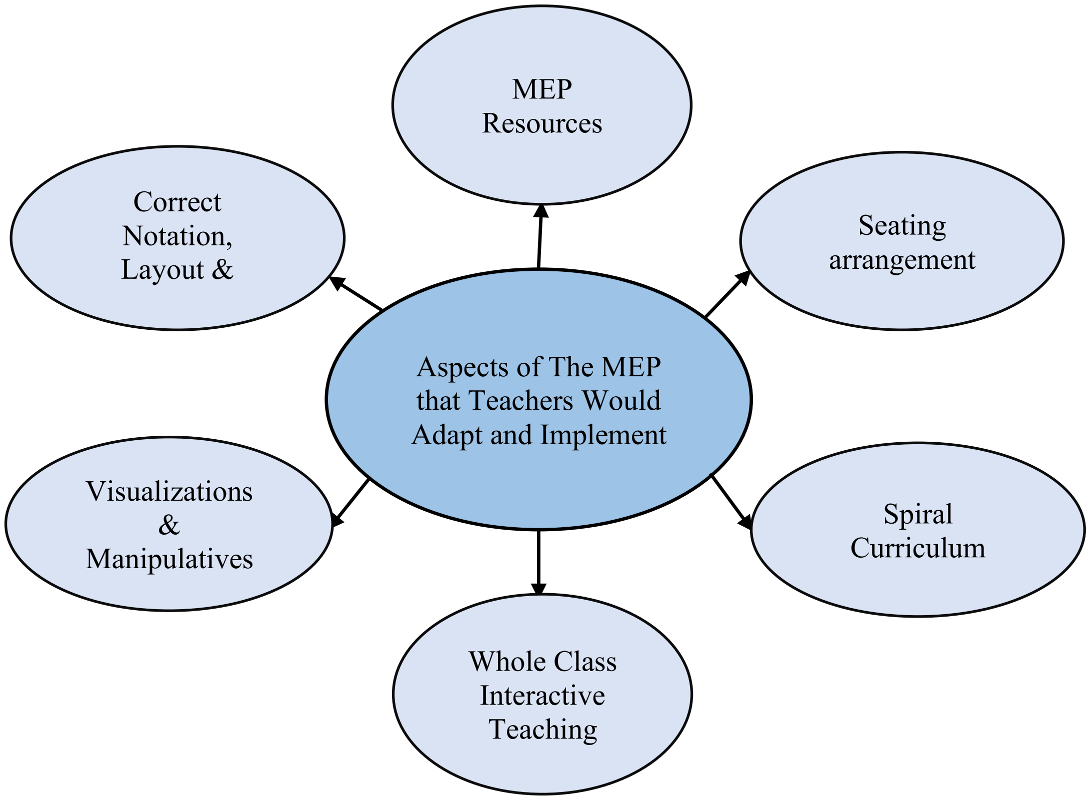


Figure 4.6.1 Aspects of the MEP that Teachers Would Adapt and Implement in their Practice

The use of correct mathematical notation, layout and language was identified by participating teachers as an aspect of the MEP that they would adapt and implement since it helps students to develop a deeper understanding of the language and correct notation of mathematics. The following are some of the precise reasons why the teachers decided that they would continue to enforce the correct use of notation, layouts and language in future math lessons:

Teacher ER: 'The correct use of the mathematical language helped my students to better understand the language of mathematics, which helped them to become better able to solve given math problem'.

Teacher CL: 'I have seen where my students became better problem solvers after I started using the correct math language, layout and notation'.

Teacher RS: '…if students understand the language and notations from an early age, it will stay with them and positively impact future studies in mathematics'.

Reacher SJ: '…placing emphasis on math vocabulary helped to build students' understanding of the math concepts that I was teaching'.

Participating teachers are of the opinion that the MEP resources (workbook, student support materials and teacher support books) had a positive impact on the teaching and learning of mathematics. It is based on this premise that teachers decided that they could continue to use these resources after the intervention. Teacher CK outlined that 'I like the structure of MEP book and how it allows students to think, I will be using activities from this book in future lessons'. Teacher AM added that 'I would continue to use the book and supporting materials like number lines and number squares because I have seen the positive impact it had on my students'. Teacher RS commented that 'the teacher support material is new to me and this really helped me to effectively use these MEP resources in my class…I like that the activities helped my students to think critically…I will continue to use the activities in this book in future lessons.' Teacher MW stated 'I like the workbooks; they are engaging and interactive. My students really enjoyed using them'. Also, teacher CL affirmed 'I will continue using the MEP resources…the workbooks are ideal for helping students develop their problem solving skills'.

The data showed that participating teachers embraced the suggested seating arrangements of the MEP and indicated that they would model this arrangement when creating their seat charts for future classes. Participating teachers suggested that when students sit where they can see the board clearly, the board is easily accessible to all students and when able students sit with the less able students, the teaching and learning process will be more effective. When students sit in a manner where they can see the board, they are better able to be visually engaged in the developmental activities facilitated by the classroom teacher (Teachers MD, MW). Teacher JY added that '…when students can easily access the board, it will be less time consuming when students volunteer or are being asked to share his/her response to a problem'. Teacher SH argued that '…some students learn better from their peers, so I will continue to use mixed ability seating in my class'.

The spiral curriculum which is an iterative revisiting of topics throughout a course (Harden, 1999) was identified by participating teachers as an aspect of the MEP that they would adapt and implement. Teachers commented that the resources that they have used before were organized in chapters based on the topics and strands that were being covered in each chapter. The data also indicate that the teachers are of the belief that when the opportunity is provided for students to continuously revise previously learnt concepts then performance in mathematics will be positively impacted (Teachers AM, MH, SH). Teacher ER shared that 'I have seen where my students are remembering more when I continuously review previously taught concepts…I will continue to model this approach in future lessons'. Teacher RS added that 'I have seen where continuous revision helped my students to grow, I will continue to use this approach to teaching in my lessons'. Additionally, teacher MW stated that 'I like the spiral curriculum that the MEP employs, I think this is good for helping our students to be continually engaged in revising previously learnt concepts; I have seen where this helps my students develop their retention of concepts learnt and their performances have also improve'.

Whole class interactive discussion was identified by participating teachers as an aspect of the MEP that they would continue to use. The data showed that teachers are of the opinion that the use of whole class interactive discussion engages the students and provides an opportunity for teachers to understand students' thought processes. As stated by teacher RS 'when I engage students in an interactive discussion, I am able to get a better understanding of how students arrive at their answers…understanding the process students use to arrive at answers has been helping me to know when remediation is needed and where it is needed'. Teacher SJ added that 'when the discussion is interactive, it benefits both students and teachers…through the interactive discussion students were integrally involved in my lessons and I know my students were learning from each other during this process…as the teacher the discussion helped me to know when to offer extra support or scaffolding'. Additionally, teacher MD commented that 'interactive discussion kept my students' engaged…the more the class discussed the work, the more students' performance was positively impacted… I will continue to facilitate discussions in this manner'.

The use of visualization and manipulatives are practices that the participating teachers indicated that they would continue to use in the teaching and learning of mathematics. The data showed that teachers are of the belief that students' critical thinking and reasoning skills were positively impacted when visualizations and manipulatives are used. This finding was supported by Moch (2002) who suggested manipulatives and visual aids are important tools in helping students to think and reason in more meaningful ways through their contribution to the development of well-grounded and interconnected understandings. The following are some of the reasons teachers intend to continue to using visualizations and manipulatives in their classes:

Teacher CK: '…manipulatives aroused my students' interest and keep them engaged…I will definitely continue to use a range of manipulatives and visual aids in my classes'.

Teacher JY: '…manipulatives and visual aids have been useful in helping to develop students understanding of various MEP math concepts…they were also useful in demonstrating various MEP math concepts…'

Teacher RS: 'My students were more engaged when I used manipulatives and visual aids in my math classes…I will continue to use these in my lessons'.

CHAPTER 5

DISCUSSION OF FINDINGS

5.0 INTRODUCTION

This chapter discusses the findings related to the integration of the MEP into Jamaican primary mathematics classes. An understanding of the background to this research and a recap of the research questions is necessary to providing the context for the systematic analysis of the research findings. For decades, Jamaica has been plagued with the issue of underperformance in mathematics (Buddo, 2017). Students' engagement has been identified as a significant contributing factor to the low levels of Jamaican students' performance in mathematics (Ministry of Education, 2011). Harris and Bourne (2017) added that poor pedagogical practices negatively affect students' engagement and subsequently academic performance.

Traditional teaching methods which are primarily based on rote memorization, drills, and recitations (Skinner 1971) have been a central part of the teaching and learning discourse in Jamaican primary mathematics classrooms. Traditional teaching methods have been found ineffective in promoting the development of conceptual understanding (Alsup and Sprigler, 2003) thus limiting students' ability to excel in these classroom settings (Battista 1994, Brandy 1999; Hiebert 2003) cited in Nesmith (2008). On the other hand, enrichment programmes have been found to be student-centred and to aid in encouraging a more expansive and in-depth learning experience for students (Fiddyment, 2014; Schnell and Prediger 2016; Taylor, 2019). The MEP which was developed based on best practices in mathematically high-performing countries (Burghes 2000; Burghes 2012) has been found to positively impact students' understanding of mathematical concepts and attainment (Binns-Thompson, Burghes and Hornby 2021; Burghes 2000, Pitman 2012; Smith 2012).

This embedded quasi-experimental research sought to investigate the impact of the MEP on students' attainment and attitude towards mathematics while investigating how the MEP was infused into the Jamaican mathematics curriculum and the challenges encountered throughout the integration. The research questions that this study was guided by are:

1. How does the implementation of the MEP impact students' performance in mathematics? (Quantitative)
2. How does the implementation of the MEP impact students' attitudes and disposition to mathematics education? (Quantitative and Qualitative)
3. What teaching strategies are used in implementing the MEP in mathematics classes? (Qualitative)
4. What do teachers consider as the most effective teaching strategies for implementing the MEP in mathematics classes? (Qualitative)
5. What do teachers consider to be the barriers to incorporating MEP resources and teaching strategies in Jamaican primary classrooms? (Qualitative)
6. Which aspects of the MEP do teachers think they will adapt and implement in their own practice? (Qualitative)

The statistical analysis of data indicated that the participants of the intervention group, taught with the MEP resources, substantially outperformed the participants of the comparison group taught with traditional teaching methods. The analysis of data also showed that the participants of the intervention group developed a more positive attitude towards mathematics than the participants of the comparison group. Qualitative analysis indicated that there are several teaching methods that can be used to integrate the MEP into primary mathematics classrooms. It was also found that there are some barriers to integrating the MEP into primary mathematics classrooms. From the data analysis it was also noted that there are aspects of the MEP that Jamaican primary school teachers of mathematics indicated that they would adapt and implement in their practices. This chapter includes a discussion of findings of the current study in relation to previous studies. At the end of this chapter major contributions and limitations of the study are discussed and recommendations for future research suggested.

5.1 RESPONSES TO THE RESEARCH QUESTIONS

This section discusses the findings on this research related to the research questions. The discussion of findings in relation to previous studies is established in this section.

5.1.1 The Impact of the MEP on Students' Attainment in Mathematics

One of the major findings of this research is that participants of the intervention group, taught using the MEP resources, made substantially greater gains than the participants of the comparison group, taught with traditional teaching methods, in their overall performance in mathematics. That is, after participating in the MEP, the intervention groups' attainment in mathematics significantly improved while the comparison groups' attainment was not significantly different. Evidence of this was noted in the differences in measures of central tendency, score variability and effect size between the pre- and post-test scores for the intervention and comparison groups. On the pre-tests a median score difference of 1 was recorded between the intervention and comparison groups (for the grade 1 participants, the median score for the comparison group was 5 out of 10 and the intervention group was 4 out of 10; for the grade 2 participants the comparison group recorded a median score of 8 of 20 and the intervention group recorded 9 out of 20). On the post-tests, participants of the intervention group recorded substantially higher median scores than the comparison group (for grade 1 participants, the comparison group recorded a median score of 9 out of 20 and the intervention group recorded 12 out of 20; for the grade 2 participants the comparison group recorded a mean score of 14 out of 40 and the intervention group recorded 24 out of 40). It was also found that the post test score variability was greater for the comparison group than for the intervention group.

Further evidence was noted in the differences in mean scores obtained for the pre-tests and post-tests. It was found that there was a greater mean difference between the pre- and post- tests for the intervention group than the comparison group. For the grade 1 participants, the mean difference between the pre- and post-tests for the comparison group was 0.18 with a standard deviation of 2.63 and an effect size of 0.068 and the mean difference between the pre- and post-tests for the intervention group was 2.83 with a standard deviation is 2.67 and an effect size of 1.06. For the grade 2 participants, the mean difference between the pre- and post-tests for the comparison group was 0.25 with a standard deviation of 2.46 and an effect size of 0.102 and the mean difference between the pre- and post-tests for the intervention group was 5.54 with a standard deviation is 5.12 and an effect size of 1.08.

As indicated by the findings of this research, the effect size for the comparison group (grades 1 and 2) is small based on the Cohen's d convention ($0.068 < 0.2$ and $0.102 < 0.2$) and the effect size of the of the intervention group (grades 1 and 2) is large ($1.06 > 0.8$ and $1.08 > 0.8$). Hattie's (2009) synthesis of meta-analysis of interventions in the field of education found that the average overall effect size, using Cohen's d statistic was 0.4. Therefore, effect sizes of 1.06 and 1.08 are well above average and can be considered to indicate a substantial impact of the MEP intervention

These findings were further supported by the results of the ANCOVA analysis which showed a significant difference in post-test scores between the two groups after adjusting for pre-test scores. The ANCOVA analysis for grade one participants recorded [$F(1,286)=119.3$, $p = .000$] with participants of the intervention group obtaining higher scores with an effect size reported at $\eta^2 = .294$. Similar results were obtained for the grade 2 participants with [$F(1,219)=120.025$, $p = .000$] and an effect size of $\eta^2 = .354$. As stated by Montgomery (2012), the eta squared effect size cut off points are small = 0.01, medium = 0.06 and large = 0.14, therefore effect sizes of η^2 = .294 and η^2 = .354 are indications of large effect sizes.

The finding that the MEP had a substantially positive impact on students' performance in mathematics supports previous research findings reported by Burghes (2000), Burghes (2012), Pitman (2012) and Smith (2012). This is similar to what was reported by Hazell (2012) who investigated 'Implementing MEP: Lessons to be learnt' and found that the MEP aided in challenging all abilities with the expectations that attainment would be positively impacted. The findings of the study reported in this thesis also support the views of Hazell (2012) who established that the MEP supports children in raising their attainment and progress and provide them with opportunities to explore their own and other's thinking. Previous studies reported that the MEP was instrumental in developing mental strategies to solve mathematics problems (Hunter, 2012) and was excellent at introducing key mathematical vocabulary and mathematical talk within lessons which facilitated students increased positive attainment in mathematics (Hazell, 2012). Additionally, in a previous study carried out by Feng (2010) it was found that students developed a greater understanding of mathematical concepts after participating in mathematics enrichment programmes. Consistent with Feng (2010), the findings of this research support the evidence that the MEP positively impacted students' understanding of mathematical concepts and achievements in the discipline (Binns-Thompson, Burghes and Hornby 2021; Burghes 2000; Pitman 2012; Smith 2012).

The findings of this research support the tenets of enrichment programmes suggested by Feng (2006) that mathematics enrichment activities such as the MEP activities aid in extending students' mathematical skills, deepening mathematical understanding, and enhancing mathematical learning processes. One way in which the MEP was found to enhance the mathematical learning processes is through the building of students' critical thinking skills. Similar to the findings of Feng (2010), the MEP, as an enrichment programme, aided in building students' critical thinking through problem-solving. Also, the students who participated in the MEP became systemic problem solvers. A range of studies has already highlighted that problem-solving is important in the teaching and learning of mathematics and mathematics programmes (Howland, 2001; NCTM, 1989; NCTM, 2000) and students' attainment in mathematics is greater when teachers place emphasis on building students critical and problem-solving skills (Mullis *et al*, 2000).

The finding that the MEP, as an enrichment programme, is more effective than traditional instruction in improving numeracy, supports previous findings regarding its role in enhancing students' attainment in mathematics (Alzoubi, 2014; Kim, 2016; Wiggins, Harding and Engelbrecht, 2017). These researchers have already positioned enriched mathematics classrooms as being effective in filling the gaps found in traditional mathematics classrooms and in positively impacting academic achievement. Evidence of this was recorded in the findings of this research which showed that students in the intervention group taught with the MEP methods and resources significantly outperformed students in the comparison group taught with traditional teaching methods. Additionally, Johnson and Sher (1997) previously found that enrichment in mathematics helps to deepen students' mathematical understanding. Also, the findings of this thesis support the view that the MEP as an enrichment mathematics programme has, 'proven to be a successful strategy because of pupils' high attainment in the discipline with a very low standard deviation' (Burghes, 2012, p.25). The findings of this study revealed that the MEP has the potential to have a global impact on attainment in mathematics. Prior to the pilot of this study, the MEP had not been implemented in a third world country. The research findings, reported in this thesis add to the existing body of knowledge that once the MEP is carefully adapted and integrated into mathematics classrooms, attainment in mathematics will be positively impacted.

5.1.2 The Impact of the MEP on Students' Attitude and Disposition Towards Mathematics

Another major finding of this research is that the students of the intervention group, taught with the MEP resources, developed a more positive attitude towards mathematics than the students of the comparison group, taught with traditional teaching methods. Higher percentage increases were observed in students' responses to items on the children's mathematics attitudinal survey that addressed positive feelings towards mathematics in the intervention group. It was also found that there was a greater increase in the number of students from the intervention group who viewed mathematics as being important in the real-world context after the intervention. The findings also indicated that there was a greater decrease in the number of students from the intervention group who thought mathematics was difficult on the post-children's mathematics attitudinal survey. Data analysis from the probe and student survey also showed that more students from the intervention group indicated that they like mathematics after the intervention. This qualitative analysis also showed that these students developed a better understanding of mathematical concepts and exhibited a greater appreciation for the discipline.

The finding that the MEP helped students to develop and display positive attitudes towards mathematics supports the previous research finding of Hunter (2012). This is consistent with the perspective that enrichment programmes such as the MEP heighten students' interest in mathematics (Feng, 2006) and improve students' attitude towards mathematics (Santos and Barmby, 2016). Prior research findings showed that after being taught mathematics with an enrichment programme, students manifested improved attitudes towards mathematics inside and outside the classroom, such as positive attitudes while working, pride in their work, having fun and built confidence in their own abilities to tackle tasks (Santos and Barmby, 2016).

The views of Jones and Simons (2000) who posit that enrichment programmes allowed students to develop deeper appreciation for mathematics is supported by the findings of this study. Furthermore, the findings of this research, which indicated that students viewed mathematics as being more interesting and one worth pursuing, is consistent with findings of Hunter (2012). Also, the finding that the MEP as a mathematics enrichment programme helps students to see the future worth of studying mathematics supports the findings of Santos and Barmby (2016). It was also previously highlighted by Santos and Barmby (2016) that mathematics enrichment programmes help students to perceive that their ability in mathematics has been improved.

The MEP was found to help students like mathematics more, enjoy mathematics more and become more confident in mathematics. This finding is similar to that reported by Santos and Barmby (2016). The finding of this study which indicated that students in the intervention group found mathematics to be fun and exciting and that their confidence in mathematics had increased supports those of Feng (2010). Feng (2010) also reported that participation in a mathematics enrichment programme helped students to become motivated to do well and excel in mathematics; she also found that the mathematics enrichment programme helped to build students' confidence and broadened their mathematical experience and horizon.

The MEP as an enrichment programme, helped students to see the applicability of mathematics in real life context. It also helped students to become more aware of the importance of mathematics in solving real world problem. This is an indication that the MEP positively impacted students' perceptions of mathematics. This supports the reports of Feng (2010) and Santos and Barmby (2016) who earlier found that enrichment programmes are instrumental in helping students to develop deeper appreciation and understanding of the real-life applicability of mathematics.

These findings provide empirical evidence that the MEP as an enrichment programme was instrumental in helping participating students develop positive attitudes and dispositions towards mathematics and that the programme is able to positively impact students' attitude toward mathematics in third world and other global settings. Based on the literature reviewed, minimal reports on the impact of mathematics enrichment programmes on students' attitude towards mathematics was reported. This new lens on the MEP's impact on Jamaican students' attitudes and dispositions towards mathematics therefore augments the existing body of knowledge.

5.1.3 Teaching Strategies used to Integrate the MEP in Jamaican Primary Mathematics Classrooms

Qualitative analysis indicated that the participating teachers incorporated the use of four main teaching strategies when integrating the MEP into their mathematics classrooms. These were class discussions, cooperative learning strategies, technology-based strategies and modelling strategies. Some of these teaching strategies have also been identified as tools in other studies. Take for example Burghes' (2012) recommendation that whole class-interactive discussions be employed as a teaching strategy while integrating the MEP was supported by the findings of this research. Smith (2012) also identified modelling as a teaching strategy that may be employed when integrating the MEP. Similarly, Piggott (2011b) previously recommended that enrichment classrooms employed the use of classroom discussions, cooperative learning (group work) and modelling teaching (making mathematical connections) strategies when developing mathematical concepts. Furthermore, the finding that active/concrete experience, physical activities and songs were infused into the teaching strategies used while integrating the MEP aligns to the research finding of Smith (2012).

Further analysis of the data showed that the participating teachers used the MEP primary resources, models, and visual aids for various lessons during the integration. This finding corresponds with the discoveries of Beston (2012) and Hazell (2012) who reported that the most positive feature of the MEP is the supporting materials that the programme provides for teachers to use while incorporating the MEP into their mathematics classrooms. During the teacher interviews it was found that teachers employed the use of teaching strategies that they thought best met the needs of their students. This is consistent with Beston's (2012) report which outlined that once the MEP is being implemented, educators used materials and strategies suitable for achievement and meeting students' needs.

The finding that when implementing the MEP, it is necessary to customize teaching methods to alleviate pupils' frustration and provide opportunities for them to advance academically supports the views of previous researchers (Bishara, 2005; Geary, 2004). Additionally, it was previously reported that, during a MEP integration, teachers flourished, enjoyed teaching mathematics, developed their mathematics pedagogical practice, and learned through trial and error that the MEP lessons lend themselves to teachers incorporating their own teaching styles (Hazell, 2012). Also, the finding that participating teachers employed the use of teaching strategies that made the integration of the MEP easier, aroused students' interest and aided in the effective development of mathematics concepts confirms previous research findings (Beston, 2012; Burghes, 2012; Hazell, 2012).

It was found that during the implementation of the MEP, participating teachers connected the mathematical concepts being developed to the cultural and social contexts of students' daily life. This finding corroborates the theories of Gay (2000, 2002, 2018) and Ladson-Billings (1995a, 1995b) who presented rationales and frameworks for developing and implementing instructional practices that connect content knowledge to students' cultural experiences and identities. Also, it was previously argued by Hunter and Hunter (2018) that establishing connections between mathematical content and students' cultural identities create opportunities for students to be successful in mathematics. The finding that participating teachers delivered the MEP content in the students' native language is consistent with the views of Moses, West and Davis (2009). Prior research findings also revealed that when learners are taught mathematics in their native language, their mathematical knowledge improved (Young, 2014). The findings of the study, reported in this thesis which showed that participating teachers incorporated the use of developmental activities that connected with students' culture while implementing the MEP supports the suggestions of Ng and Rao (2010) who argued that mathematical notions should be specific to students' culture. They further maintained that such a connection positively impacts mathematics education and attainment in mathematics.

The findings of the study reported in this thesis which connected MEP lessons to students' cultural experiences and identities, add to the existing body of knowledge. They provide information to the international mathematics educational arena on ways the MEP can be modified to nurture and support students' cultural competences while maintaining the deep structures of the MEP. It was also added that teachers can integrate mathematics enrichment activities within their classrooms while being culturally responsive. Specifically, the findings of this study have added to the existing body of knowledge that the MEP is adaptable and can be implemented globally in mathematics classrooms to address the learning needs of students while sustaining their culture. The research findings of this thesis also add information on teaching strategies that may be employed to effectively implement the MEP into mathematics classrooms while sustaining students' culture.

5.1.4 Most Effective Teaching Strategies for Integrating the MEP into Jamaican Primary Classrooms

From the data analysis, whole class interactive discussions, the cooperative learning strategy think-pair-share, the technology-based strategy multimedia presentations, and the modelling teaching strategy of scaffolding have been found to be most effective for integrating MEP lessons. Qualitative data analysis from teacher interviews indicated that these strategies were most effective because teachers found that teaching and learning discourses were most effective and more students demonstrated mastery of the MEP content when these strategies were employed during the integration. It was previously suggested by Piggott (2007) that when implementing mathematics enrichment programmes, teachers need to create an atmosphere in which students are engaged in dialogues and interactions such as modelling. This, Piggott (2007) believes helps to create a community where learners are involved in developing appropriate language that enhances communication for sharing ideas and individual communal sense-making.

The findings of this study support the views of Smart (2011) who purported that whole class (open) discussion encouraged students to listen to their peers, formulate their own understanding and demonstrate a good understanding of the concepts being developed. Smart (2011) also highlighted that open discussions as a teaching method in implementing mathematics enrichment programmes is a successful tool which aides in students demonstrating significant increases in their understanding of mathematical concepts. Also, the finding that modelling and discussion are effective strategies for integrating the MEP because of their role in helping students to become critical independent thinkers supports the views of Piggott (2007).

Prior research studies have presented teaching strategies that may be employed when implementing mathematics enrichment programmes. These studies have also identified the benefits of varying teaching strategies as tools for implementing such programmes. The findings of this study add the teaching strategies found to be more effective for integrating the MEP, to the existing body of knowledge. The benefits of incorporating these teaching strategies when implementing the MEP was also added.

5.1.5 Barriers to Integrating the MEP into Primary Mathematics Classrooms

Another major finding of this study is that there are various barriers to integrating the MEP into existing mathematics classrooms. From the data analysis the barriers to integrating the MEP were found to be limited classroom amenities and resources, challenging MEP content and pace, teacher-based barriers, time consuming and technology-based barriers. The barrier of teachers being resistant to change endorses the previous research findings of Beston (2012) and Smith (2012). In the study conducted by Beston (2012) that examined the early innovations of the MEP, it was revealed that it is difficult for teachers to change the fundamental way that they teach. The findings of this research which indicated that participating teachers viewed the MEP as being demanding and time consuming supports the findings of Pitman (2012).

Another barrier to integrating the MEP, identified in this thesis and was previously reported by Burghes (2012), Hazell (2012) and Pitman (2012) is that of the MEP content and pace difficulties. Prior research reports have detailed that the MEP's content and pace was challenging for both teachers and students when initially implemented (Burghes, 2000; Hazell, 2012). It was also suggested that teachers' well-developed mathematical subject knowledge is important for mitigating the content demands of the MEP and for ensuring its effective integration (Burghes, 2012; Burghes and Hunter, 2012).

In addition to the barriers noted in the empirical literature examined, limited classroom amenities and resources and technology-based barriers were identified in this study. This study provides evidence that there are potential infrastructural barriers to be considered when integrating the MEP or other enrichment programmes into third world mathematics classrooms in countries that face economic hardships.

5.1.6 Aspects of the MEP that Teachers would Adapt and Implement in Their Practice

Qualitative data analysis showed that there are aspects of the MEP that participating teachers thought were worth adapting and implementing in their practices. From the teacher interviews it was found that the aspects of the MEP most likely to be adapted by the participating teachers are the MEP resources, MEP recommended seating arrangements, spiral curriculum, whole class interactive teaching, visualizations, and manipulations, as well as correct notation, layout, and language. Participating teachers detailed that they would continue to implement the use of these aspects of the MEP in their daily lessons because of the positive impact they had on teaching and learning in their individual classrooms. Based on the testimonials of the teachers, these aspects of the MEP aided in improving their practices and subsequently left a positive impact on the teaching and learning of mathematics. This confirms the view that the MEP provides ample opportunities for educators to develop good classroom practices (Hazell, 2012). Also, in a previous study conducted by Santos and Barmby (2016) it was found that, after teachers participated in mathematics enrichment programmes, they felt energized and motivated to change their practice to incorporate more engaging and problem-based learning activities in everyday teaching, learning and doing mathematics.

The finding that teachers expressed an interest in adapting aspects of the MEP because of the positive effect that they had on the teaching and learning of mathematics corroborates the findings of previous studies (Burghes, 2012; Hunter, 2012; Kellet, 2012; McAleavy, 2012). Similarly, Pitman (2012) reported that the MEP aids in the teaching of mathematics, the development of staff capacity and strengthening the learning community, which is supported by the findings of this study. Further evidence was documented by Kellett (2012) who outlined that the MEP emphasized the accurate use of mathematical terms, thus equipping students with the skill sets to be able to effectively explain answers and excel (Kellet, 2012). A prior study also reported that the MEP emphasizes the correct use of mathematical language and communication which aids in building critical thinking and positively impacting attainment (Hunter 2012). The finding of the MEP's spiral curriculum being beneficial to the teaching and learning of mathematics and hence being adaptable supports the argument put forward by McAleavy (2012). McAleavy (2012) also argued that the spiral curriculum employed during the implementation of the MEP allows for the continual review of previously learnt mathematical concepts and is essential in helping students demonstrate mastery in mathematics.

The findings of this study, reported in this thesis add specific features of the MEP that teachers thought were worth adapting and implementing in their practices to the existing body of knowledge. Empirical evidence of the impact of each of these aspects on the teaching and learning of mathematics was also added from the lens of the participating teachers. The findings of this study also suggest that the features of the MEP may have a positive global impact on the teaching and learning of mathematics.

5.2 THE EFFECT OF THE MEP ON THE TEACHING AND LEARNING OF MATHEMATICS

The findings of this research, which support the findings of previous studies indicated that the unique features of the MEP, built on best practices born out of mathematically high performing countries (Burghes, 2012), had a significant positive impact on the teaching and learning of mathematics (Burghes, 2012; Hazell, 2012; Hunter, 2012; Kellett, 2012; McLeavy; 2012; Pitman, 2012; Smith 2012). The finding of the MEP positively impacting students' performance and attitude towards mathematics supports previous research (Burghes, 2012; Hazell, 2012; Hunter, 2012; Kellett, 2012; McLeavy, 2012; Pitman, 2012; Smith 2012). The increase in students' performance and positive attitude towards mathematics after participating in the intervention is considered to be a result of the features and structure of the MEP. As suggested by Beston (2012) the features, structure and the different levels of support provided by the MEP is essential to effecting positive changes in the teaching and learning of mathematics. The students in the intervention group had their experiences of learning mathematics transformed as their individualized needs were being catered for with the integration of the MEP into their mathematics classroom. This finding supports previous arguments by Hazell (2012) who found that the MEP provides a holistic support for teachers, and it helps to equip them with the requisite skills needed to address the misconceptions identified in the teaching and learning of mathematics. This kind of support and development of skill sets contributed to the positive teaching and learning experiences gained by the participants in the intervention group.

The support system provided for teachers throughout the implementation of the MEP made it easier for teachers to effectively integrate the programme into their mathematics classes. It was also previously found that the opportunities provided by the MEP helped educators develop good classroom practices (Hazell, 2012). This view was supported by the findings of the research where it was observed that participating teachers became more aware of and implemented effective classroom practices in the teaching and learning of mathematics. The practices developed mirrored the best practices of mathematically high performing countries that the MEP was built on (Burghes, 2012) and played a significant role in the effective integration of the MEP into primary classes. The implementation of the MEP and subsequent development of good classroom practices positively impacted students' attitudes and performance in mathematics.

The comprehensive nature of the MEP required teachers to participate in lesson study sessions geared at developing the skill sets necessary for the effective integration of the MEP. The support participating teachers received through lesson study and the teacher support materials provided aided in sharpening their pedagogical skill sets and provided them with first-hand best practices for effectively developing of mathematical concepts. This observation supports previous research which indicated that lesson study plays an important role in the implementation of the MEP (Beston, 2012). It enables teachers to develop their own strategies for integrating the MEP (Burghes, 2012) as it is aimed at equipping teachers with the skills needed to make mathematics enjoyable for students while improving their understanding of the logic and rigour needed for mathematics (Burghes and Hunter, 2012). The lesson study feature of the MEP is another advantage the participants in the intervention group benefitted from, which also aided in the significant positive impact that the programme had on the teaching and learning of mathematics.

5.3 SIGNIFICANCE AND IMPLICATIONS OF FINDINGS

The findings from the research reported in the thesis, coupled with supporting evidence from the literature showed that there are substantial benefits to be derived from integrating the MEP into mathematics classes. These findings will help make mathematics educators and policy makers aware of the positive impact that the implementation of a mathematics enrichment programme can have on the teaching and learning of mathematics. It also provides evidence of teaching methods and techniques that may be employed for the effective implementation of the MEP and similar initiatives into mathematics teaching. The findings reported in this thesis will also make mathematics educators and policy makers aware of potential issues that may occur when incorporating an enrichment programme into mathematics classes.

The findings of this research linked to research question one imply that the implementation of the MEP in primary mathematics classrooms had a substantial positive impact on students' attainment in mathematics. Evidence of this was noted with the significant mean differences and effect sizes recorded after the intervention. This is a clear indication that the integration of the MEP aided in building students analytical and critical thinking skills and mathematical fluency. This finding will make teachers of mathematics and policy makers aware of the potential impact of the MEP on the teaching and learning of mathematics in their context and subsequently the numeracy achievement outcomes of their nations.

Additionally, the findings of this study indicated that the MEP positively impacted students' attitudes towards mathematics. This is evident in the results reported from the analysis of the pre- and post-children's mathematics attitudinal surveys where it was found that students expressed a more positive attitude towards mathematics after being taught with the MEP programme and resources. This finding will aid in making educators aware of the extent to which mathematics enrichment programmes can facilitate the development of positive attitudes towards mathematics. Insight into the effect of the MEP on students' attitude towards mathematics will allow teachers of mathematics and policy makers to make informed decisions on adapting and implementing the MEP in their mathematics classrooms.

The findings of this research also indicated that there are numerous teaching strategies that can be used to integrate the MEP into mathematics classrooms. The teaching strategies which involved discussions, cooperative learning strategies, technology-based strategies and modelling were found to aid in arousing students' interest, increasing student participation and positively impacting students' retention. These findings will enable teachers of mathematics and policy makers, who are interested in adapting and implementing the MEP to become aware of the different teaching strategies that may be used to facilitate the integration. Also, these findings highlighted the potential impact of the varying teaching strategies used in the MEP. This will help educators who adapt this programme to be better able to make informed decisions that best meet the learning needs of the students they serve.

The research findings highlighted that there are barriers to integrating the MEP into classroom practice for teaching mathematics. The barriers that were found and reported in this thesis are classroom amenities, challenging MEP content and pace, teacher-based barriers, time consuming and technology-based barriers. Knowledge of the possible barriers to integrating the MEP will help administrators and curriculum developers seeking to adapt and implement the MEP to plan and implement innovative ways to mitigate the possible effect of the barriers. Take for instance the barrier identified as challenging MEP content. To help in overcoming this barrier, administrators would need to ensure that teachers' mathematics subject knowledge is enhanced, offer mathematics subject knowledge enhancement training where necessary, and offer CPD sessions throughout the integration. This would aid in equipping teachers with the depth of mathematical content knowledge and the requisite skill sets needed to foster the concrete development of mathematical concepts and to help students overcome challenges encountered with the content and problem-solving.

5.4 LIMITATIONS OF THE STUDY

This study contributes to the existing body of knowledge on the impact of integrating a mathematics enhancement programme in primary mathematics classrooms. There are however some notable limitations to this study which may affect the generalizability of its results. Firstly, the participating teachers were conveniently selected from the set of primary teachers who were previously trained in the mathematics Subject Knowledge Enhancement Programme (SKE). The SKE training was aimed at building and updating teachers' mathematical knowledge, thus enabling them to be ready for the mathematical teaching and learning discourses involved in the MEP (NCTL, 2015). The training which ran over 10 months aided teachers to develop the requisite skills needed to effectively guide students into developing in-depth understanding of the mathematical concepts during teaching and learning discourses (Ball, Thames and Phelps, 2008; French, 2005). Their respective classes formed the intervention group. Similarly, the participating teachers from the comparison group, also trained in SKE, were conveniently chosen. Although, this study employed the use of a true comparison group taught only with traditional teaching methods and care was taken to eliminate confounding variables, the lack of randomization could limit the generalizability of the findings of this research.

Secondly, this study was limited to one academic year and only involved a total of 12 classes from three schools across Jamaica forming the intervention group. That is, seven grade 1 classes consisting of 189 students and five grade 2 classes consisting of 142 students. Also, the number of participants in the comparison group was less than the number in the intervention group. The comparison group involved a total of 7 teachers from two primary schools in Jamaica, that is 4 grade one classes consisting of 100 students and three grade 2 classes consisting of 80 students. Ideally, a longer experimental period on a larger scale involving more participants from more primary schools across more parishes in Jamaica would provide more rigour and accuracy to the evaluation of the intervention. Thirdly, the study did not include a follow-up to evaluate whether the positive effect of the MEP was maintained over time. Fourthly, very few empirical studies have been conducted to compare the effects between the Mathematics Enhancement Programme and traditional teaching methods. The limited available literature and supporting evidence from prior research made it difficult to compare this research with other studies in the same field.

Another factor that may affect the validity of this research is the use of self-report instruments. The information collected by means of a self-reported instrument in the form of children's mathematics attitudinal survey was used to measure students' attitude towards mathematics. As put forward by Gay, Mills and Airasian (2009) self-reported instructions such as attitude and interest scales are notably limited because of the possibility of a response set which drives individuals to respond in a particular way to a variety of instruments. Self-reported instruments increase the likelihood of participants providing responses that they think are more socially acceptable even if it is not reflective of their own situation. Take for instance, when responding to item 8 'mathematics is hard for me', the participants' responses may be influenced by extrinsic factors. That is some responses presented may reflect older relatives or other trusted adults' views of the difficulty of mathematics. Evidence of this was noted on a pre-survey response when a student indicated that 'mommy and daddy say mathematics is hard, so it is hard'. This is, therefore, not a true reflection of the child's own feelings towards the hardship of mathematics but a reflection of how he was coached to view mathematics. Although the MEP took measures to help students develop their own feelings towards mathematics by making the subject fun, motivating and relevant, and by building students' analytical skills, for students like these who are extrinsically motivated, their responses may be reflective of a specific response set.

The interpretation of the results of this study can provide only an emerging understanding of the process and impact of integrating the MEP into Jamaican classrooms. Consideration should be given to the possibility of bias in the interpretation of results as these may be influenced by the researcher's views and other interpretations are possible. Although the researcher attempted to be impartial when analysing the data, the possibility of bias exists since the interpretation of findings may be influenced on the researcher's perception of how knowledge is acquired and her views about the efficacy of the MEP.

Finally, another factor that may result is potential research bias is the possible Hawthorne effect of the intervention. The Hawthorne effect in educational research occurs when research participants act in a way that is consistent with their perception of the researcher's expectations during a study, which can then bias the outcomes of that study. In this study it is possible the teachers in the experimental group may have been more dedicated to their teaching than those in the comparison group because they were enthusiastic about implementing the MEP and this could have influenced the progress of their students. So, although the participants were young and had very little direct interaction with the researcher, it is still possible that being part of an experiment motivated them to work harder. Nevertheless, it is considered that the very significant gains seen in attainment and attitudes are very unlikely due solely to the Hawthorne effect.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

To address the limitations of this study and to facilitate more rigorous research, a number of recommendations are provided in this section. First to increase the generalizability and quality of studies, it is recommended that future researchers seeking to investigate the impact of integrating a mathematics enrichment programme such as the MEP employ a completely randomized comparative experiment. That is, participants in both the intervention group, taught with the programme's lessons and resources, and participants in the comparison group (taught with the traditional teaching methods) should all be randomly assigned. This will aid in mitigating any research bias caused by the groups differing.

To foster greater generalizability, it is recommended future research employ random selection of participants from the country's entire population of primary school students. This would allow for the intervention to be replicated in several classrooms across the country and among students with more diverse learning needs. Once conducted using a more representative sample, researchers will be better able to generalize the impact of mathematics enrichment programmes on the teaching and learning of mathematics. Also, more generalized inferences may be made based on findings of research done in this context.

It is also recommended that future studies linked to the integration of mathematics enrichment programmes be conducted for a longer research period. Longitudinal research with follow-up studies would be more effective in confirming the impact of mathematics enrichment programmes on the teaching and learning of mathematics. It would be a good way to measure the extent to which participants' attitude and performance in mathematics is impacted over different grade levels while they are taught mathematics with the mathematics enrichment programme resources.

5.6 RECOMMENDATIONS FOR PRACTICE

Teachers, schools, educations systems

To address the issue of underperformance in mathematics and provide a guide for mathematics educators, curriculum developers and policy makers seeking to adapt and implement best pedagogical practices, a number of recommendations are provided in this section. First, to address the issue of under-performance in mathematics, it is recommended that governing Ministries of Educations, mathematics educators and curriculum developers seek to adapt or develop mathematics enhancement programmes based on the best practices of mathematically high performing countries. That is, the mathematics enrichment programmes, possibly adapted or further developed should have research evidence of effecting positive changes in the teaching and learning of mathematics. Secondly, mathematics educators and curriculum developers need to perform formative assessments of the students that they serve. The results from the assessments along with research evidence should be used as a guide for selecting the teaching strategies that may be employed for the effective integration of mathematics enrichment programmes. It is also recommended that math educators embrace the constructivist teaching method when integrating such programmes, since it aids in creating opportunities for full student engagement.

It is strongly recommended that ministries of education seeking to integrate a mathematics enrichment programme like the MEP firstly create opportunities to enhance their teachers' mathematics subject knowledge. As put forward by Adler *et al.* (2014), teachers' subject knowledge of the mathematical content covered in the school curriculum should be deeper than that of their students. French (2005) opined that a teacher's ability to prepare effective lessons and to respond perceptively and flexibly to the multitude of difficulties that pupils encounter with mathematics is dependent on their own depth of understanding of the topics involved and their own powers of mathematical thinking as well as their more general pedagogical skills and understanding. Ball, Thames, and Phelps (2008, p. 400) endorsed this view when they posited that 'Teaching requires knowledge beyond that being taught to students', and teachers require what they call 'unpacked' mathematical knowledge which they use to teach 'decompressed mathematical knowledge' to learners so that students eventually 'develop fluency with compressed mathematical knowledge'. It is therefore important that teachers are equipped with the requisite subject knowledge to effectively integrate a mathematics enrichment programme into their classrooms.

When integrating a mathematics enrichment programme, it is recommended that teachers take the time to familiarize themselves with the programme's materials (lessons, activities and resources). Teachers must have a deep conceptual understanding of the programme's material in order to foster an effective integration and to meet the diverse needs of the students. It is also important for teachers to be familiar with the materials to be able to effectively address any issues or misconceptions that students may have.

It is also recommended that policy makers and curriculum developers examine the potential barriers to integrating a mathematics enrichment programme and devise strategies to mitigate the impact of these barriers. Take, for instance, the barrier of teachers being resistant to change. To minimize the impact of this barrier on any possible integration, policy makers, principals and math coaches will need to educate teachers about the importance of a mathematics enrichment programme and the benefits to be gained from integrating such programmes into mathematics classrooms. Care should also be taken to help teachers build their confidence in the chosen MEP and adequate training should be provided so that teachers will feel confident about accommodating a change in their pedagogical practices.

Finally, it is recommended that administrators, curriculum developers and mathematics coaches provide continuous support in the form of professional development and lesson study sessions, for teachers integrating a mathematics enrichment programme. For most teachers, integrating a mathematics enrichment programme for the first time may be challenging, but teachers who are supported throughout the process tend to remain in the programme and work cohesively with their peers to overcome the challenges. Also, when teachers are supported, they can share their successes and challenges in a safe place, learn from each other's experience and work as a team to effect positive changes in the teaching and learning of mathematics.

5.7 FINAL THOUGHTS

Enriched mathematics classrooms have been filling educational gaps and have been positively impacting achievement (Alzoubi, 2014; Kim 2016; Wiggins, Harding and Engelbrechr, 2017). The MEP as an enrichment programme provides an opportunity for educators to develop good classroom practices (Hazell, 2012). The MEP challenges all abilities with the expectation that attainment will be impacted (Hazell, 2012).

Based on the findings discussed in this research, it can be concluded that the MEP has the potential to positively revolutionize mathematics education. The programme provides teachers with ample resources and the training required to effect change in their practice. It also allows teachers the flexibility to implement the use of the teaching strategy that is best for meeting their students' needs, while integrating the use of its resources. The MEP was found to have positively impacted students' attainment and attitude towards mathematics. The findings of this research make it evident that the MEP has the potential to positively impact mathematics education in various settings in a developing country. This suggests that the MEP, once carefully and effectively implemented, has the potential to globally impact mathematics education worldwide and in particular in countries with developing economies such as Jamaica. It is hoped that the findings of this research will be identified by researchers, policy makers and mathematics educators as a productive model that may be adapted and implemented to effect positive changes in mathematics education worldwide.

The researcher's horizon on mathematics teaching and the research process was broadened after conducting this research. It was made more apparent that the teaching of mathematics involves much more than just the dissemination of information. Conducting this research made it clear that the teaching of mathematics should be aimed at meeting the learning needs of all students. Also, teachers of mathematics need to develop the flexibility to integrate the teaching strategies of the mathematics enrichment programmes that will positively impact the teaching and learning of mathematics.

The experiences garnered from conducting this study allowed the researcher to develop in-depth understanding of the research process. Additionally, it was made apparent that scholarly research needs rigor in order to be efficient and effective. It was also learnt that to be patient, dedicated and hardworking are attributes all researchers need to possess. Conducting research is time consuming and it can be challenging. Researchers, therefore, need to be dedicated to the task to ensure that success is achieved. The researcher's individual research skill sets have been developed over the course of this study. The researcher is better prepared to conduct future research studies because of the experiences gained from completing this thesis.

REEFERENCES

Aarts, S., Akker, M. and Winkens, B. (2013) ‘The importance of effect sizes’, *European Journal of General Practices*, 20(1), pp. 61-64. Available at: https://www.tandfonline.com/doi/full/10.3109/13814788.2013.818655 (Accessed: 3 January 2022).

Adler, J., Hossain, S., Stevenson, M., Clarke, J., Archer, R. and Grantham, B. (2014) ‘Mathematics for teaching and deep subject knowledge: voices of Mathematics Enhancement Course students in England’, J*ournal of Mathematics Teacher Education*, 17:129–148. Available at: https://link.springer.com/article/10.1007/s10857-013-9259-y (Accessed: 30 January 2021).

Alim, H. S. and Paris, D. (2017) ‘What is culturally sustaining pedagogy and why does it matter?’, in Paris, D. (eds) and Alim, H. S. *Culturally sustaining pedagogies: teaching and learning for justice in a changing world*. New York: Teachers College Press, pp 1-23. Available at https://www.google.com/books/edition/Culturally_Sustaining_Pedagogies/4tYnDwAAQBAJ?hl=en&gbpv=1&dq=borrow+culturally+sustaining+pedagogies:+teaching+and+learning+for+justice+in+a+changing+world&printsec=frontcover (Accessed: 3 June 2023).

Alsup, J. and Sprigler, M. (2003) ‘A comparison of traditional and reform mathematics curricula in an eighth-grade classroom’, *Journal of Education* 123(4), pp. 689+. Available at: https://www.questia.com/library/journal/1G1-105043947/a-comparison-of-traditional-and- reform-mathematics (Accessed: 21 March 2019).

Alzoubi, S.M. (2014) ‘Effects of enrichment programs on the academic achievement of gifted and talented students’, *Journal for the Education of the Young Scientist and Giftedness*, 2(2), pp. 22-27. Available at: http://jegys.org/admin/b_bilgi_dosya/dosya/20112014170052_jeysg-2-2-3.pdf (Accessed: 2 January 2019).

Amit, M. and Fried, M.N. (2002) ‘Research, reform, and times of change’ in L. D. English (ed) *Handbook of international research in mathematics education*, Mahwah, NJ: Erlbaum pp. 355-81.

Annisa, M., Aan, H. and Tatang, H. (2019) ‘Analysis of students mathematical understanding viewed from visual and visual-auditory learning styles’, *International Seminar. STEMEIF (Science, Technology Engineering and Mathematics Learning International Forum)*, pp. 386–393.

ARC Center. (2001) *Tri-state student achievement study*. Available at: http://www.comap.com/product/?idx=965 (Accessed: 20 January 2021).

Ardeleanu, R. (2019) ‘Traditional and modern teaching methods in mathematics’ *Journal of Innovation in Psychology, Education and Didactics*, 23(2), pp. 133-144. Available at: https://search.proquest.com/openview/2998ca4178b5c9ea6eff77c7a9141518/1?pq-origsite=gscholar&cbl=2055403 (Accessed: 28 December 2020).

Ary, D., Jacobs, L. and Razavieh, A. (2002) *Introduction to research.* 6th edn. Belmont: Wadsworth.

Baba, T. (2007) 'Japanese education and lesson study: An Overview', in M. Isoda, M. Stephen, Y. Ohara and T. Miyakawa (eds.) *Japanese lesson study in mathematics: its impact, diversity and potential for educational improvement.* Singapore: World Scientific Publishing, pp. 2-7.

Ball, D.L. (1990) 'The mathematical understandings that prospective teachers bring to teacher education', *Elementary School Journal*, 90, pp. 449-466. Available at: https://www.jstor.org/stable/1001941 (Accessed: 17 June 2021).

Ball, D., Bass, H. and Hill, H. C. (2004) 'Knowing and using mathematical knowledge in teaching: learning what matters', in A. Buffgler & R. Lausch (eds.), *Proceedings for the 12th Annual Conference of the South African Association for Research in Mathematics, Science and Technology Education*, pp. 51-65, Durban: SAARMSTE.

Ball, D., Thames, M. and Phelps, G. (2008) 'Content knowledge for teaching: what makes it special' *Journal of Teacher Education*, 59(5), pp. 389-407. Available at: https://www.academia.edu/28835113/Content_Knowledge_for_Teaching_What_Makes_It_Special (Accessed: 1 January 2021).

Barmby, P., Bolden, D. and Thompson, L. (2014) *Understanding and Enriching Problem Solving in Primary Mathematics*. Northwich: Critical Publishing.

Barron, B., Pea, R. and Engle, R.A. (2013) 'Advancing understanding of collaborative learning with data derived from video record', in C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, and A. O'Donnell (eds) *The international handbook of collaborative learning*. New York: Routledge, pp. 203–219.

Battista, M. (1994) 'Teacher beliefs and the reform movement in mathematics education' *Phi Delta Kappan*, 75(6), pp. 462-463, 466-468, 470.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., et al. (2010) 'Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress' *American Educational Research Journal*, 47(1), 133–180. Available at: https://www.researchgate.net/publication/43125103_Teachers%27_Mathematical_Knowledge_Cognitive_Activation_in_the_Classroom_and_Student_Progress (Accessed 13 November 2022).

Berger, M. (2005) 'Vygotsky's theory of concept formation and mathematics education', in Chick, H. L. & Vincent, J. L. (Eds.). *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*, 2, pp. 153-160. Melbourne: PME, 10-15 July. Available at https://files.eric.ed.gov/fulltext/ED496819.pdf (Accessed: 12 July 2023)

Beston, Y. (2012). 'MEP: Early innovations', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp. 29-32.

Binns-Thompson, S.K.K., Hornby, G. and Burghes, D. (2021). Investigating the impact of a mathematics enhancement programme on Jamaican students' attainment', *Education Sciences*, 11(9), 516. Available at: https://doi.org/10.3390/educsci11090516 (Accessed: 15 September 2021).

Bishara, S. (2005) *Characteristics of school and improvement in achievements in basic areas of learning in reading comprehension and mathematics in students of special education in the Jewish and Arabic sectors.* PhD thesis. University, Ramat-Gan. (In Hebrew). Available at: https://education.biu.ac.il/en/node/2711 (Accessed: 12 February 2020).

Bishara, S. (2018) 'Active and traditional teaching, self-image, and motivation in learning math among pupils with learning disabilities', *Cogent Education*, 5(1). Available at: https://www.cogentoa.com/article/10.1080/2331186X.2018.1436123 (Accessed: 2 January 2019).

Blanco, L. J., Barona, E. G. and Carrasco, A.C. (2013) 'Cognition and affect in mathematical problem solving with prospective teachers', *The Mathematics Enthusiast*, 10(1), pp. 335-363. Available at https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=1270&context=tme (Accessed: 8 August 2023).

Block, J. H. and Anderson, L. W. (1975) *Mastery learning in classroom instruction*. New York: Macmillan.

Block, J. H., and Burns, R. B. (1976) 'Mastery learning', *Review of Research in Education*, 4(1), pp. 3–49. Available at https://doi.org/10.3102/0091732X004001003 (Accessed: 4 August 2023)

Bloom, B. S. (1968) 'Learning for mastery', *Evaluation comment*, 1(2), pp. 1-11. Available at https://files.eric.ed.gov/fulltext/ED053419.pdf (Accessed: 4 August 2023

Bono, M.A. (2002) 'Reform in mathematics education: rethinking the curriculum', *Interdisciplinary Journal of Graduate Studies*. Available at: https://concept.journals.villanova.edu/article/view/313/276 (Accessed 12 December 2021).

Borchelt, N. (2007) 'Cognitive computer tools in the teaching and learning of undergraduate calculus', *International Journal for the Scholarship of Teaching and Learning*, 1(2), pp. 1-17. Available at https://files.eric.ed.gov/fulltext/EJ1137017.pdf (Accessed: 20 June 2023).

Bourne, P.A. (2019) 'Mathematics performance in Jamaica' *International Journal of History and Scientific Studies*, 1(4), ISSN 2581-8767, pp. 08-31. Available at: https://www.researchgate.net/publication/333203993_MATHEMATICS_PERFORMANCE_IN_JAMAICA (Accessed: 12 December 2020).

Bourne, P. A. (2022) 'An examination of mathematics performance in Jamaica: Insights into the basis of low enrolment in mathematics at the tertiary level', *International Journal of Transformation in Applied Mathematics and Statistics'*, 5(1), pp. 1-38. Available at https://www.researchgate.net/publication/367348154_An_Examination_of_Mathematics_Performance_in_Jamaica_Insight_into_the_basis_for_low_enrolment_in_Mathematics_at_the_tertiary_level#fullTextFileContent (Accessed: 16 November 2023).

Bourne, P.A., Evans, D., Brown, N., Golding, S., Grant, L., Green, K., Rose., C., Solomon, T. and Thorpe C. (2017) 'Modeling in the teaching of mathematics: changing attitude and performance. Is this the way forward?', *International Journal of Transformation in Applied Mathematics and Statistics*, 2(1). Available at: https://www.academia.edu/38129613/Z_Article_Text (Accessed: 14 January, 2021).

Boyd, P. and Ash, A. (2018) 'Mastery Mathematics: changing teacher beliefs around in-class grouping and mindset', *Teaching and Teacher Education*, 75, pp. 214-223. Available at https://insight.cumbria.ac.uk/id/eprint/4002/1/Boyd_MasteryMathematics_pubpdf.pdf (Accessed: 20 July 2023).

Briars, D.J. and Resnick, L.B. (2000) 'Standards, assessments and what else?', *The essential elements of standards-based school improvement*, Los Angeles: Center for the Study of Evaluation, Center for Research on Evaluation, Standards, and Student Testing, California University. Available at: https://cresst.org/wp-content/uploads/TECH528.pdf (Accessed: 20 April 2021).

Brief History of Jamaica (no date). Available at: https://www.ducksters.com/geography/country.php?country=Jamaica (Accessed: 10 September 2020).

Brierley, J.A. (2017) 'The role of a pragmatist paradigm when adopting mixed methods in behavioural accounting research', *International Journal of Behavioural Accounting and Finance*, 6(2), pp. 140-154. Available at: https://eprints.whiterose.ac.uk/115066/3/pragmatism-ijbraf-paper.pdf (Accessed: 30 December 2021).

British Educational Research Association [BERA] (2018) *Ethical guidelines for educational research*. 4th edn. London: BERA Available at: https://www.bera.ac.uk/researchers-resources/publications/ethical- guidelines-for-educational-research-2018 (Accessed: 9 August 2021).

Bryman, A. (2006) *Mixed methods: a four-volume set.* Thousand Oaks, CA: Sage.

Buddo, C. (2015) 'Teachers' reflections on their implementation of a revised primary mathematics curriculum', *International Journal of Education and Research* 3(15). Available at: https://www.ijern.com/journal/2015/December-2015/16.pdf (Accessed: 30 May 2022).

Buddo, C. (2017) 'Mathematics education: a case for problem solving', *The Jamaican Observer*, Available at: http://www.jamaicaobserver.com/columns/Mathematics-education--A-case-for-problem-solving_90150 (Accessed: 15 March 2019).

Burghes, D. (2000) ‘Mathematics Enhancement Programme: the First 3 Years’. Available at: https://www.cimt.org.uk/projects/mep/intrep00.pdf (Accessed 1 Sep. 2018).

Burghes, D. (2012) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust.

Burghes, D. and Hunter, J (2012) ‘Recommendations for good practice’ in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp. 97-104

Burns, A. (1999) *Collaborative action research for English language teachers*. Cambridge: CUP

Caldera, A (2021) *What the term “culturally sustaining practices” means for education in today’s classroom.* Available at https://www.idra.org/resource-center/what-the-term-culturally-sustaining-practices-means-for-education-in-todays-classrooms/#:~:text=Culturally%20sustaining%20pedagogy%20maintains%20heritage,bi%2D%2Fmultilingualism%20and%20multiculturalism (Accessed: 12 June 2023).

Campton, I. and Stephenson, M. (2014) ‘Partnering theory and practice in mathematics teaching’, in R. Hyde and J.A. Edwards (eds.) *Mentoring mathematics teachers: supporting and inspiring pre-service and newly qualified teachers*, Abingdon: Routledge.

Castro, F. G., M. Barrera, and C. R. Martinez. 2004. The cultural adaptation of prevention interventions: resolving tensions between fidelity and fit. *Prevention Science* 5 (1): 41–45. Doi: 1389-4986/04/0300-0041/1

Chapman, O. (1997) ‘Metaphors in the teaching of mathematical problem solving’, *Educational Studies in Mathematics*, 32, pp. 201-228. Available at: https://doi.org/10.1023/A:1002991718392 (Accessed: 4 March 2019).

Chinnappan, M. and Cheah, U. (2012) ‘Mathematics knowledge for teaching: evidence from lesson study’ in J. Dindyal, L.P. Cheng and S. F. Ng (eds) *Mathematics education: expanding horizons,* proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia, Singapore: MERGA. Available at: https://files.eric.ed.gov/fulltext/ED573192.pdf (Accessed: 12 February 2021).

Chiu, M.S. (2009). Approaches to the teaching of creative and non-creative mathematical problems. *International Journal of Science and Mathematics Education, 7*, 55-79. https://doi.org/10.1007/ s10763-007-9112-9

Chiu, M. *et al.* (2022) ‘The interplay of affect and cognition in the mathematics grounding activity: Forming an affective teaching model’, *EURASIA Journal of Mathematics, Science and Technology*, 18(12), pp. 2-15. Available at https://www.ime.ntnu.edu.tw/wp-content/uploads/the-interplay-of-affect-and-cognition-in-the-mathematics-grounding-activity-forming-an-affective-12579.pdf (Accessed: 27 July 2023).

CIMT (no, date) *Mathematics Enhancement Programme Primary Resources*. Available at https://www.cimt.org.uk/projects/mepres/primary/index.htm (Accessed 12 April 2017)

CIMT (2018) *Mathematics Enhancement Programme Jamaica Primary Resources.* Available at https://www.cimt.org.uk/projects/mepres/primary/jamaica/index.htm (Accessed: 1 March 2018).

Clark, V.P. and Creswell, J.W. (2011) *Designing and conducting mixed-methods research*. 2nd edn. Los Angeles: Sage.

Clements, D.H. and Battista, M.T. (2009) 'Constructivist learning and teaching' *The National Council of Teachers of Mathematics, Inc.* Available at: www.nctm.org. (Accessed: 16 December 2019).

Clendening, C.P. and Davies, R.A. (1983) *Challenging the gifted: curriculum enrichment and acceleration models*. New York: Bowker.

Coffelt, T.A. (2017) 'Confidentiality and anonymity of participants', in M. Allen (ed) *The SAGE Encyclopedia of Communication Research Methods*. Thousand Oaks, CA: Sage, pp 227-230. Available at: https://dx.doi.org/10.4135/9781483381411.n86 (Accessed: 30 December 2021).

Cohen, L., Manion, L., and Morrison, K. (2000) *Research methods in education*. 5th edn. London: Routledge.

Cohen, L., Manion, L., and Morrison, K. (2007) *Research methods in education*. 6th edn. London: Routledge Falmer.

Creswell, J.W. (1998) *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks, CA: Sage

Creswell, J. W. (2003) *Research design: Qualitative, quantitative and mixed methods approaches.* 2nd edn. Thousand Oaks, CA: Sage

Creswell, J. W. (2006a). *Designing and conducting mixed method research: choosing a mixed method designs*. Chapter 3. Available at: https://www.sagepub.com/sites/default/files/upm-binaries/35066_Chapter3.pdf (Accessed: 1 May 2019).

Creswell, J. W. (2006b) *Designing and conducting mixed method research: choosing a mixed methods design*. Chapter 4. Available at https://www.sagepub.com/sites/default/files/upm-binaries/10982_Chapter_4.pdf (Accessed: 10 June 2021).

Creswell, J. W. (2008) *Educational research: planning, conducting, and evaluating quantitative and qualitative research*. 3rd edn. Upper Saddle River, NJ: Pearson Education.

Creswell, J. W. (2012) *Educational research: planning, conducting, and evaluating quantitative and qualitative research*. 4th edn. Upper Saddle River, NJ: Pearson Education.

Creswell, J. W. (2014) *Research design: qualitative, quantitative and mixed methods approaches.* 4th Edn. Thousand Oaks, CA: Sage.

Creswell, J. W., & Plano Clark, V. L. (2010) *Designing and conducting mixed methods research.* 2nd edn. Thousand Oaks, California: Sage.

Creswell, J. W. & Plano Clark, V.L. (2011) *Designing and conducting mixed methods research*.
Thousand Oaks: Sage.

Cropper, J. (2021) *6 fascinating Jamaican traditions and customs.* Available at https://www.roughguides.com/article/6-fascinating-jamaican-traditions-and-customs/ (Accessed 29 June 2023).

Crossfield, D. and Bourne, P.A. (2017) 'Education professionals' perceptions of factors that contribute to effective mathematics teaching and achievement in Jamaica', *International Journal of Research in Humanities and Social Studies,* 4(12), pp. 1-10. Available at:
https://www.ijrhss.org/papers/v4-i12/1.pdf (Accessed: 26 May 2022).

Dahir, A. L. (2017) *The land of Haile Selassie is finally recognizing its Rastafarian community*. Available at: https://qz.com/africa/1042140/ethiopia-the-land-of-haile-selassie-is-finally-recognizing-its-rastafarians-by-issuing-them-identity-cards/ (Accessed 29 March 2021).

Das, K. (2020) 'Realistic mathematics and Vygotsky's theories in mathematics education', *International Journal of Education*, 9(1), pp. 104 -108. Available at https://files.eric.ed.gov/fulltext/EJ1278172.pdf (Accessed: 25 June 2023)

David, M., Edwards, R., and Alldred, P. (2001) 'Children and school-based research: 'informed consent' or 'educated consent'?' *British Educational Research Journal, 27*(3), pp. 347-365. Available at: http://www.jstor.org/stable/1501900 (Accessed: 9 August 2021).

Davis, N. (2010) *The essential guide to customs & culture: culture smart! Jamaica*. London: Kuperald. Available at
https://www.google.com/books/edition/Jamaica_Culture_Smart/sXEFAQAAQBAJ?hl=en&gbpv=1&dq=jamaica+culture&printsec=frontcover (Accessed 29 June 2023).

Davis, R. (2004) *Task force on educational reform, Jamaica: a transformed education system*. Available at:
https://jis.gov.jm/estp/docs/Reports/JA%20Education%20Reform%20TaskForce%202004.pdf (Accessed: 13 May 2020).

Davis, B., and Simmt, E. (2006) 'Mathematics-for-teaching: an ongoing investigation of the mathematics that teachers (need to) know' *Educational Studies in Mathematics*, 61(3), pp. 293–319.

DeBellis, V. A., & Goldin, G. A. (2006) 'Affect and meta- affect in mathematical problem solving: a representational perspective', *Educational Studies in Mathematics, 63*(2), 131-147. Available at https://doi.org/10. 1007/s10649-006-9026-4 (Accessed: 27 July 2023)

Dennis, D. (2014) *A brief history of Ja's modern economic performance: the rise and fall*. Available at: http://www.jamaicaobserver.com/columns/a-brief-history-of-ja-s-modern-economic-performance--the-rise-and-fall-_17759523 (Accessed: 20 August 2020).

Denscombe, M. (2008) 'Communities of practice: a research paradigm for the mixed methods approach', *Journal of Mixed Methods Research*, 2(3), pp.270-283.

Dixson, A. D. and Fasching-Varner, K. J. (2009) 'This is how we do it: helping teachers understand culturally relevant pedagogy in diverse classrooms', in C. Compton-Lilly (ed.) *Breaking the silence: recognizing the social and cultural resources students bring to the classroom*. Newark, DE: International Reading Association, Inc, pp. 34-48.

Drew, C.J., Hardman, M.L. and Hosp, J.L. (2008) *Designing and conducting research in education*. Thousand Oaks, CA: Sage.

Economy (no date). Available at: http://countrystudies.us/caribbean-islands/24.htm (Accessed 10 October 2020).

Education (no date). Available at: http://countrystudies.us/caribbean-islands/22.htm (Accessed: 20 December 2020).

Education in Jamaica (no date). Available at: https://www.studycountry.com/guide/JM-education.htm (Accessed: 17 December 2020).

Edwards, R., Hydel, R., O'Connor. M., and Oldham, J. (2015) 'The importance of subject knowledge for mathematics teaching: an analysis of feedback from Subject Knowledge Enhancement Courses', *Proceedings of the British Society for Research into learning mathematics*, 34(3) November 2015. Available at https://eprints.soton.ac.uk/387221/1/BSRLM-IP-35-3-07.pdf (Accessed: 25 January 2021).

Ernest, P. (2000) 'Teaching and learning mathematics', in V. Koshy *et al*. (eds) *Mathematics for primary teachers*. London: Routledge.

Ernest, P. (2009) 'New philosophy of mathematics: implications for mathematics education', in B. Greer, S. Mukhopadhyay, A. Powell and S. Nelson-Barber (eds.) *Culturally responsive mathematics education*. New York, NY: Routledge pp. 43–64.

EU (2002). Key competencies. Brussels: EU Directorate General for Education and Culture.

Eurydice (2010) *New skills for new jobs*. Brussels: Eurydice. Available at: https://eurydice.indire.it/wpcontent/uploads/2017/06/New_Skills_New_Jobs_2010_EN.pdf (Accessed: 18 July 2021).

Febrianti, D. N. and Purwaningrum, J. P. (2021) 'Jerome Bruner's theory of learning to improve basic school students' understanding of numbers by learning in stage', *Mathematics Education Journals*, 5(1), pp. 46-57. Available at http://ejournal.umm.ac.id/index.php/MEJ (Accessed: 11 July 2023).

Feilzer, M.Y. (2010) 'Doing mixed methods research pragmatically: implications for the rediscovery of pragmatism as a research paradigm', *Journal of Mixed Methods Research,* 4, pp. 6-16.

Feng, W.Y. (2006) 'Conceptions of mathematics enrichment', *British Educational Research Association (BERA) Annual Conference* at University of Warwick, 6-9 September.

Feng, W.Y. (2010) *Students experience of mathematics education*. Available at: https://bsrlm.org.uk/wp-content/uploads/2016/02/BSRLM-IP-30-1-11.pdf. (Accessed: 25 January 2022).

Fiddyment, G.E. (2014) 'Implementing enrichment cluster in elementary schools: lessons learned', *Gifted Child Quarterly*, 58, pp. 287-296. Available at: https://www.academia.edu/23157010/Implementing_Enrichment_Clusters_in_Elementary_Schools_Lessons_Learned (Accessed: 12 June 2020).

*Five Oldest High Schools in Jamaica (*2015). Available at: http://digjamaica.com/m/blog/child-month-5-oldest-high-schools-in-jamaica/ (Accessed: 20 December 2020).

French, D. (2005) 'Subject knowledge and pedagogical knowledge', *Proceedings of the meeting on where will the next generation of UK mathematicians come from*?, Manchester 18-19 March. Available at: http://www.ma.umist.ac.uk/~avb/pdf/DougFrenchSubjectKnowledge.pdf (Assessed: 22 February 2019).

Fritz-Stratmann, A. (2013) 'Development of mathematical concepts as basis for an elaborated mathematical understanding', *South African Journal of Childhood Education*, 3(1). Available at: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2223-76822013000100004 (Accessed: 1 Feb. 2019).

Galloway, C.M. (2001) 'Vygotsky's constructionism', in M. Orey (ed.). *Emerging perspectives on learning, teaching, and technology*. Switzerland: Jacob Foundation, pp. 48-49. Available at https://textbookequity.org/Textbooks/Orey_Emergin_Perspectives_Learning.pdf (Accessed: 15 July 2023

Gay, G. (2000) *Culturally responsive teaching: theory, research and practice.* New York: Teachers College Press.

Gay, G. (2002) 'Preparing for culturally responsive teaching', *Journal of Teacher Education*, 53(2), pp. 106–116. Available at https://doi.org/10.1177/0022487102053002003 (Accessed: 20 June 2023)

Gay, G. (2018) *Culturally responsive teaching: theory, research and practice.* 3rd edn. edited by J. A. Banks. University of Colombia: Teachers College Press.

Gay, L.R., Mills, G E., and Airasian, P. (2009) *Educational research: competencies for analysis and applications.* 9th edn. London: Pearson Education.

Geary, D.C. (2004) 'Mathematics and learning disabilities', *Journal of learning disabilities*, *37*(1), pp. 4-15. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.413.1307&rep=rep1&type=pdf (Accessed: 13 February 2021).

Gibbs, G.R. (2007) 'Analyzing qualitative data: 4 thematic coding and categozing', in U. Flick (ed) *The Sage qualitative research kit.* Thousand Oaks, CA: Sage, pp. 38-55.

Goldin, G. A. (2000) 'Affective pathways and representation in mathematical problem solving', Mathematical *Thinking and Learning*, 2, pp. 209-219. Available at https://doi.org/10.1207/S15327833MTL0203_3 (Accessed: 27 July 2023)

Gómez-Chacón, I. M. (2000) 'Affective influences in the knowledge of mathematics', *Educational Studies in Mathematics*, 43, pp. 149-168. Available at DOI: 10.1023/A:1017518812079

Gómez-Chacón, I. M. (2005) 'Affect, mathematical thinking and intercultural learning; A study on educational practice', *European Society for Research in Mathematics Education*. Available at https://core.ac.uk/download/pdf/19724777.pdf (Accessed: 20 July 2023)

Gooden, L. (2003) *Reggae Heritage: Jamaica's music history, culture and politics*. USA: 1st Books.

Gordon, S. (1963) *A century of West Indian education*. London: Longmans.

Grady, M., Watkins, S. and Montalvo, G. (2012) *The effect of constructivist mathematics on achievement in rural schools*. Available at: https://files.eric.ed.gov/fulltext/EJ987623.pdf (Accessed 20 January 2021).

Greenes, C. (2008) 'Mathematics learning and knowing: a cognitive process', *The Journal of Education*, 189(3), pp. 55-64. Available at: http://www.jstor.org/stable/42744269 (Accessed: 19 March 2021).

Guba, E. and Lincoln, Y.S. (2005) 'Paradigmatic controversies and emerging confluences', in N.K. Denzin and Y.S. Lincoln (eds) *The SAGE handbook of qualitative research.* 3rd edn., Thousand Oaks, CA: Sage, pp. 191–216.

Guskey, T. R. (1997) *Implementing mastery learning*. 2nd edn. Belmont, California: Wadsworth Publishing Company.

Guskey, T. R. (2000) *Evaluating professional development*. California: Corwin Press Inc.

Guskey, T. R. and Gates, S. L (1986) 'Synthesis of research on the effects of mastery learning in elementary and secondary classroom', *Educational leadership*, 43(8), pp. 73-80. Available at https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1017&context=edp_facpub (Accessed: 4 August 2023).

Hackmann, D.G. (2004) 'Constructivism and block scheduling: making the connection', *Phi Delta Kappan*, 85(9), pp. 697-702. Doi: 10.1177/003172170408500911.

Hall, R. (2013a) *Mixed methods: in search of a paradigm*. Available at: https://www.researchgate.net/publication/259045135_Mixed_Methods_In_search_of_a_paradigm (Accessed: 21 December 2021).

Hall, S. (2013b) 'Thinking the diaspora: home-thoughts from abroad', in A. Kamugisha (ed.) *Caribbean political thought: theories of the post-colonial state*. Jamaica: Ian Randle Publishers, pp. 380–394.

Hannula, M. S. (2012) 'Exploring new dimensions of mathematics-related affect: embodied and social theories', *Research in Mathematics Education, 14(2)*, pp. 137-161. https://doi.org/10.1080/14794802.2012. 694281.

Hannula, M. S. (2019) 'Young learners' mathematics- related affect: a commentary on concepts, methods, and developmental trends', *Educational Studies in Mathematics,* 100, pp. 309-316. https://doi.org /10.1007/s10649-018-9865-9.

Harden, R.M. (1999) 'What is a spiral curriculum?', *Medical Teacher*, 21(2), pp. 141-143. Available at: http://dx.doi.org/10.1080/01421599979752 (Accessed 29 November 2021).

Harris, J. and Bourne, P. A. (2017) 'Perception of teachers and pupils on factors influencing academic performance in mathematics among a group of fifth and sixth graders in Jamaica', *Eureka Journals,* 1(1).

Hastings, J. (2015) Jamaica Takes Big Steps Towards Improving its Educational System. Available at: **https://www.worldbank.org/en/results/2015/09/16/jamaica-big-steps-improving-educational-system** (Accessed: 10 October 2020).

Hattie, J. (2009) Visible *learning:a synthesis of over 800 meta-analyses relating to achievement.* Routledge London: UK. Available at: https://apprendre.auf.org/wp-content/opera/13-BF-References-et-biblio-RPT-2014/Visible%20Learning_A%20synthesis%20or%20over%20800%20Meta-analyses%20Relating%20to%20Achievement_Hattie%20J%202009%20...pdf (Accessed: 25 June 2021).

Hausfather, S. J. (1996) 'Vygostky and schooling: creating a social contest for learning', *Action in Education*, 18(2), pp. 1-10. Available at https://doi.org/10.1080/01626620.1996.10462828 (Accessed: 6 July 2023).

Hazell, M. (2012) 'Implementing MEP: Lessons to be learned', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp. 33-38.

Hickling-Hudson, A. R. (2000) 'Postcolonialism, hybridity and transferability: the contribution of Pamela O'Gorman to music education in the Caribbean' *Caribbean Journal of Education*, 22(1&2), pp. 36–55. Available at https://eprints.qut.edu.au/3503/1/3503.pdf (Accessed: 10 June 2023)

Hickling-Hudson, A., Matthews, J. and Woods, A. (2004) 'Education, postcolonialism and disruptions', in A. Hickling-Hudson, J. Matthews, and A. Woods (eds.) *Disrupting preconceptions:postcolonialism and education*. Available at https://www.researchgate.net/publication/40590606_Education_postcolonialism_and_disruptions (Accessed: 19 June 2023)

Hill, H. C., Ball, D.L. and Schilling, S.G. (2004) 'Developing measures of teachers' mathematics knowledge for teaching', *Elementary School Journal*, 105(1), pp. 11-30.

Holness, C. (no date) *Jamaica parishes: their history, capital & landmark attractions*. Available at: https://www.my-island-jamaica.com/jamaica_parishes.html (Accessed 12 December 2020).

Howland, M. (2001) *Sixth-grade students' use of schema knowledge in word problem solving.* Master's thesis. San Jose State University. Available at: https://doi.org/10.31979/etd.xsba-px8w (Accessed: 29 July 2020).

Hunte, C. (1976) *The development of higher education in the West Indies special emphasis on Barbados*. Doctoral dissertation. WA: Washington State University.

Hunter, J. (2012a) 'Pupils' perspectives and attitudes towards learning mathematics following implementation of the Mathematics Enhancement Project', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp. 76-82.

Hunter, J. (2012b), 'Developing teacher understanding of early algebraic concepts using lesson study', in J. Dindyal, L. P. Cheng and S. F. Ng (eds) *Mathematics education: expanding horizons (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia)*. Singapore: MERGA. Available at: https://files.eric.ed.gov/fulltext/ED573270.pdf (Accessed: 11 January 2022).

Hunter, J. and Back, J. (2011) 'Facilitating sustainable professional development through lesson study', *Mathematics Teacher Education and Development*, 13(1), pp. 94-114. Available at: https://files.eric.ed.gov/fulltext/EJ960951.pdf (Accessed: 11 January 2022).

Hunter, R. and Hunter, J. (2017) 'Maintaining a cultural identity while constructing a mathematical disposition as a Pāsifika Learner', in E.A. McKinley and L.T. Smith (eds) *Handbook of indigenous education*. Singapore: Springer Nature Singapore Pte Ltd. Available at https://smep.sites.arizona.edu/sites/smep.sites.arizona.edu/files/Hunter&Hunter-2017.pdf (Accessed: 20 September 2023).

Hunter, R. and Hunter, J. (2018) 'Opening the space for all students to engage in mathematical practices within collaborative inquiry and argumentation', in R. Hunter, M. Civil, B. Herbel-Eisenmann, N. Planas, and D. Wagner (eds.) *Mathematical discourse that breaks barriers and creates space for marginalized learners*. The Netterlands:Rotterdam, pp. 1-22. Available at https://doi.org/10.1163/9789463512121_001

Hylton, K. (2002) *Promoting a mathematics-positive classroom*. Available at https://www.jamaicaobserver.com/career-education/promoting-a-mathematics-positive-classroom/ (Accessed: 24 August 2023).

Hynes, K. O'Connor, S. and Chung, A. M. (1999) *Literacy: exploring strategies to enhance learning in after-school programs*. Boston, MA: Wellesley College Center for Research on Women.

Ifamuyiwa, A.S. and Ajilogba, S.I. (2012) 'A problem solving model as a strategy for improving secondary school students: achievement and retention in further mathematics', *ARPN Journal of Science and technology*, 2(2), pp. 122-130. Available at: http://www.ejournalofscience.org/archive/vol2no2/vol2no2_18.pdf (Accessed: 12 January 2019).

Innabi H. and Emanuelsson, J. (2020) 'Enrichment in school principals' ways of seeing mathematics', *International Journal of Mathematical Education in Science and Technology*, 52(10), pp. 1508-1539 Available at: https://www.tandfonline.com/doi/full/10.1080/0020739X.2020.1782496 (Accessed: 13 January 2021).

Isoda, M. (2010) 'Lesson study: problem solving approaches in mathematics education as a Japanese experience', *Procedia-Social and Behavioral Sciences*, 8 pp. 17-27. Available at: https://www.researchgate.net/publication/251712950_Lesson_Study_Problem_Solving_Approaches_in_Mathematics_Education_as_a_Japanese_Experience (Accessed: Feb 10 2021).

Israeli, T. (2008). *The connection between alternative assessment by means of research tasks, and the motivation and achievements in science in primary schools in the state-religious system*. Master's thesis. Bar-llan University Ramat-Gan.

Jamaica history & background (no date). Available at: https://education.stateuniversity.com/pages/725/Jamaica-HISTORY-BACKGROUND.html (Accessed: 10 October 2020).

Jamaica Information Services (no date) *The history of Jamaica*. Available at: https://jis.gov.jm/information/jamaican-history/ (Accessed: 22 August 2020).

Jamaica overview (2020). Available at: https://taxsummaries.pwc.com/jamaica (Accessed: 5 December 2020).

JCDC (2018) *Competitions: traditional folk forms.* Available at http://vtdics.com/vtdics.com/jcdc/jcdc.gov.jm/jcdc.gov.jm/competitions/traditional-folk-forms.html (Accessed: 1 July 2023).

Jervier, W. S. (1979) Review of *educational change in postcolonial Jamaica*. Edited by R. Cummings. *Comparative Education Review*23(1), pp. 160-161. Available at https://www.jstor.org/stable/1187641 (Accessed: 20 July 2023)

Jett, C. C. (2013) 'Culturally responsive collegiate mathematics education: implications for African American students', *Interdisciplinary Journal of Teaching and Learning*, 3(2), pp 102-116). Available at https://rsccd.edu/Departments/Diversity-Initiative/PublishingImages/Pages/Diversity-in-Teaching-and-Learning/Culturally%20Responsive%20Collegiate%20Mathematics%20Education.pdf (Accessed: 29 June 2023).

Johnson, R.B. and Onwuegbuzie, A.J. (2004). 'Mixed methods research: a research paradigm whose time has come', *Educational Researcher, 33*(7), pp. 14-26.

Johnson, R.B., Onwuegbuzie, A.J. and Turner, L.A. (2007) 'Toward a definition of mixed methods research', *Journal of Mixed Methods Research, 1*(2), pp. 112-133.

Johnson, D.T. and Sher, B.T. (1997) *Resource guide to mathematics curriculum materials for high-ability learners in grades K-8*. College of William and Mary, School of Education, Center for Gifted Education.

Jones, K. and Simons, H. (2000) 'The student experience of online mathematics enrichment', *Proceedings of the 24th Conference of the International Group for the Psychology of Mathematics Education*, Hioshima, Japan, 23-27. Available at: https://www.researchgate.net/publication/252948140_The_student_experience_of_online_mathematics_enrichment (Accessed: 12 December 2020).

Kapur, R. (2018) 'The impact of culture on education'. Available at https://www.researchgate.net/publication/323794724_Impact_of_Culture_on_Education (Accessed: 14 June 2013).

Karatas, I. and Baki, A. (2013) 'The effects of learning environments based on problem solving on students' achievements of problem solving', *International Electronic Journal of Elementary Education*, 5(3), pp. 249-268. Available at: https://files.eric.ed.gov/fulltext/EJ1068620.pdf (Accessed: 2 March 2020).

Kashti, Y., Arieli, M. and Shlansky, S. (1997) *Lexicon of education and teaching*. Special edn. Jerusalem: Teachers Union.

Kellett, S. (2012) 'Starting in the nursery', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp (63-75).

Kim, M. (2016) 'A meta-analysis of the effects of enrichment programs on gifted students', *Gifted Child Quarterly*, 60(2), pp. 102–116. DOI: 10.1177/0016986216630607.

Klinger, C. M. (2011) 'Connectivism: a new paradigm for mathematics anxiety challenge?', *Adult Learning Mathematics: An international Journal*, 6(1), pp. 7 – 19. Available at: https://files.eric.ed.gov/fulltext/EJ1068259.pdf (Accessed: 24 July 2020).

Knight, J. and Rapley, J. (2007) *Educational reform in Jamaica: recommendations from Ireland, Finland and Singapore.* Available at: https://www.capricaribbean.org/sites/default/files/public/documents/working_paper/education_reform.pdf (Accessed: 10 October 2020)

Kraft, M. A. (2020) 'Interpreting effect sizes of education interventions', *Sage Journal*, Available at: https://journals.sagepub.com/doi/full/10.3102/0013189X20912798 (Accessed: 3 January 2022).

Krauss, S., Baumert, J., and Blum, W. (2008) 'Secondary mathematics teachers' pedagogical content knowledge and content knowledge: validation of the COACTIV constructs', *ZDM Mathematics Education*, 40(5), pp. 873–892. doi:10.1007/s11858-008-0141-9.

Kuncorowati, R. H., Mardiyana, M., and Saputro, D. R. S. (2017) 'The analysis of student's difficulties based on Skemp's Understanding Theorem at the grade VII in quadrilateral topic', *International Journal of Science and Applied Science: Conference Series*, 2(1), pp. 318–328. Available at https://pdfs.semanticscholar.org/5df0/81a48031e1a9904d2bca342a7de37b205226.pdf?_gl=1*91pykw*_ga*OTgzNTM0NzM4LjE2OTAxMDI2NDc.*_ga_H7P4ZT52H5*MTY5MDEwMjY0Ny4xLjEuMTY5MDEwMjY3NC4zMy4wLjA. (Accessed: 10 July 2023).

Ladson-Billings, G. (1995a) 'Toward a theory of culturally relevant pedagogy', *American Educational Research Journal*, 32(3), pp. 465-491. Available at: http://lmcreadinglist.pbworks.com/f/Ladson-Billings%20(1995).pdf (Accessed: 20 June 2023).

Ladson-Billings, G. (1995b) 'But that's just good teaching! The case for culturally relevant pedagogy', *Theory Into Practice*, 34(3), pp. 159-165. Available at http://www.jstor.org/stable/1476635 (Accessed: 12 June 2023).

Ladson-Billings, G. (2009) *The dreamkeepers: successful teachers of African American children* (2nd ed.). San Francisco, CA: Jossey-Bass.

Lanante, M. G. A. (2019) *Effect of problem-solving enrichment activities on mathematics achievement: a case of elementary pupils in the central parts of Philippines*. Available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3900116 (Accessed: 10 November 2023).

Lewis, C. (2002) *Lesson Study: a handbook of teacher-led instructional change*. Philadelphia: Research for Better Schools.

Lewis, C., and Hurd, J. (2011) *Lesson study step by step: how teacher learning communities improve instruction*. Portsmouth, NH: Heinneman.

Lewis, C. and Perry, R. (2013) 'Lesson study with mathematical resources: a sustainable model for locally-led teacher professional learning', *Mathematics Education Research Group of Australasia.* Available at: https://files.eric.ed.gov/fulltext/EJ1046670.pdf (Accessed: 4 February 2021).

Lewis, C., Perry, R.R., and Hurd, J. (2009) 'Improving mathematics instruction through lesson study: a theoretical model and North American case', *Journal of Mathematics Teacher Education*, 12, pp. 285-304. Available at: https://www.lessonstudygroup.net/lg/readings/ImprovingmathematicsinstructionthroughlessonstudyAtheoreticalmodelandNorthAmericancaseLewisCPerryRHurdJ/ImprovingmathematicsinstructionthroughlessonstudyAtheoreticalmodelandNorthAmericancaseLewisCPerryRHurdJ.pdf
(Accessed: 13 February 2021).

Lim, C. S (2007) 'Developing mathematical thinking in a primary mathematics classroom through lesson study: An exploratory study', *Proceedings of the APEC-Khon Kaen International symposium on Innovative Teaching Mathematics through Lesson Study (II): Focusing on mathematical thinking*. Khon Kaen: Thailand, pp. 141-153.

Lockheed, M., Harris, A., Gammill, P., Barrow, K. and Jayasundera, T. (2006) 'New horizons for primary schools in Jamaica: inputs, outputs and impact', *United States Agency for International Development; Academy of Educational Development*. Available at: https://files.eric.ed.gov/fulltext/ED498851.pdf (Accessed: 23 May 2022).

Ma, L. (1999) *Knowing and teaching elementary mathematics: teachers' understanding of fundamental mathematics in China and the United States*. New Jersey: Lawrence Erlbaum.

Mack, L (2010) 'The philosophical underpinnings of educational research'. Available at: https://en.apu.ac.jp/rcaps/uploads/fckeditor/publications/polyglossia/Polyglossia_V19_Lindsay.pdf (Accessed: 12 July 2021).

Maclellan, E. (2014) 'Articulating 'understanding': Deploying mathematical cognition', *Scottish Educational Review* 46(2), pp. 73-89. Available at: https://doi.org/10.1163/27730840-04602006 (Accessed: 7 July 2023)

Martin, D. B. (2009) 'Liberating the production of knowledge about African American children and mathematics', in D. B. Martin (ed.) *Mathematics teaching, learning and liberation in the lives of black children.* New York, NY: Routledge pp. 3–36.

McAleavy, T. (2012) *Exploring approaches to teaching primary maths*. Available at: https://www.theguardian.com/teacher-network/2012/jul/20/primary-maths-programme (Accessed: 12 July 2020)

McClowry, S. and M. Spellmann (2016) 'Assessing the cultural relevance of INSIGHTS for Jamaica', *Caribbean Journal of Education*, 38(1), pp 73-93. Available at https://insightsintervention.com/wp-content/uploads/2020/01/McClowry-Spellmann-2016-Jamaica.pdf (Accessed 28 June 2023).

McLeod, S. (no date) *Bruner's Theory of Constructivism.* Available at https://evaeducation.weebly.com/uploads/1/9/6/9/19692577/bruner.pdf (Accessed: 5 June 2023).

McLeod, D. B. (1992). Research on affect in mathematics education: a reconceptualization, in D. A. Grouws (Ed.) *Handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics*. Washington: Macmillan Publishing Co, Inc, pp. 575-596.

Mcleod, S. 2023 *Vygotsky's sociocultural theory of cognitive development*. Available at https://www.simplypsychology.org/vygotsky.html (Accessed: 2 August 2023)

Merriam, S.B. (1998) *Qualitative and case study applications in education*. San Francisco: Jossey-Bass.

Merriam, S.B. (2001) *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Meyer, R. D., and Wilkerson, T. L. (2011) 'Lesson study: the impact on teachers' knowledge for teaching mathematics', in Hart, L.C., Alston, A. S., and Murata, A. (eds) *Lesson study research and practice in mathematics education*. Dordrecht: Springer, pp. 15-28.

Michaelides, M. (2008) 'Emerging themes from early research on self-efficacy beliefs in school mathematics', *Electronic Journal of Research in Educational Psychology*, 6(1), pp. 219-234. Available at https://www.redalyc.org/pdf/2931/293121940008.pdf (Accessed: 4 August 2023)

Miles, M.B. and Huberman, A.M. (1994) *Qualitative data analysis*. 2nd edn. Thousand Oaks, CA: Sage

Miller, E. (2018) *Educational reform in independent Jamaica*. Available at: https://errolmiller.com/wp-content/uploads/2018/01/Education-Reform-in-Independent-Jamaica.pdf?89108e&89108e (Accessed: 10 October 2020).

Milwood, K. (2021) 'Jamaica: the beauty of its culture and language', *Day transition blog* , 28 July. Available at https://www.daytranslations.com/blog/jamaica-the-beauty-of-its-culture-and-language/ (Accessed 26 June 2023).

Mimon, K. (2008) *The effect of coaching on task interpretation on achievement in the task, pedagogical self-efficacy and motivation in learning among teaching flowers*. MA thesis. School of Education, Bar Ilan University, Ramat-Gan.

Ministry of Education (2001) *Education: The way upward-A path for Jamaica's education at the start of the new millennium*. Kingston, Jamaica: MoEC.

Ministry of Education (2011) *The National Comprehensive Numeracy Programme.* Available at https://moey.gov.jm/wp-content/uploads/2015/05/NCNPMOEHandbook.pdf (Accessed 12 July 2020)

Ministry of Education. (2012) *National Education Strategic Plan (NESP)*: 2011-2020. Available at: https://www.mona.uwi.edu/cop/library/jamaica-national-education-strategic-plan-2011-2020 (Accessed: 12 June 2019)

Ministry of Education (2013) *National mathematics policy guidelines.* Available at https://moey.gov.jm/sites/default/files/National%20Mathematics%20Policy%20Guidelines%20(2013).pdf (Accessed: 12 June 2019).

Ministry of Education (2014) *Jamaica education for all review 2015*. Available at: http://stceddepart.weebly.com/uploads/4/0/5/9/4059456/jamaica_education_review.pdf. (Accessed: 12 July 2021).

Ministry of Education and Youth (No Date) *Education repositories statistics.* Available at: https://moey.gov.jm (Accessed: 12 November 2018).

Ministry of Education, Youth and Culture. (2009-2010). *Jamaican education statistics 2009-2010.* Kingston, Jamaica

Ministry of Education, Youth and Information (2017) *Chief inspector's report: Cycle 2 Round 2 Re-Inspection.* Available at: https://www.nei.org.jm/Portals/0/Content/Documents/Chief%20Inspector's%20Report%202017.pdf?ver=2018-11-30-102446-537&ver=2018-11-30-102446-537 (Accessed: 13 January 2019).

Misnasanti, Dien, C.A., and Azizah, F. (2018) 'The roles of lesson study in the development of mathematics learning instrument based on learning trajectory' (from the sessions presented at the International Conference of Mathematics, Science and Education, Semarang, Indonesia, 18-19 September 2017) *Journal of Physics: Conference Series*, 983 (2018) 012103. Available at: https://iopscience.iop.org/article/10.1088/1742-6596/983/1/012103/pdf (Accessed: 6 February 2021).

Moch, P. (2002) 'Manipulatives work!', *The educational forum*, *66*(1), pp. 81-87. Available at: http://www.tandfonline.com.proxy.lib.wayne.edu/doi/pdf/10.1080/00131720108984802 (Accessed: 15 July 2020).

Montgomery, D. C. (2012). *Design and analysis of experiments.* 8th edn. Hoboken, NJ, USA: John Wiley and Sons.

Montilla, J. R. B. (2019) 'Behaviourism: its implication to mathematics education'. Available at https://www.researchgate.net/publication/338149249_BEHAVIOURISM_ITS_IMPLICATION_TO_MATHEMATICS_EDUCATION (Accessed: 25 March 2021).

Morgan, D.L. (1998) 'Practical strategies for combining qualitative and quantitative methods: Applications to health research', *Qualitative health research, 8*(3), pp. 362-376.

Morgan, D.L. (2007) 'Paradigms lost and pragmatism regained: methodological implications of combining qualitative and quantitative methods', *Journal of Mixed Methods Research*, 1(1), pp. 48-76.

Moses, R., West, M. M. and Davis, F. E. (2009) 'Culturally responsive mathematics education in the Algebra Project', in B. Greer, S. Mukhopadhyay, A. Powell and S.

Nelson-Barber (eds.) *Culturally responsive mathematics education*. New York, NY: Routledge, pp. 239–256.

Mullis, I.V. S., Martin, M.O., Gonzalez, E.J., Gregory, K.D., Garden, R.A., O'Connor, K.M., Chrostowski, S.J., and Smith, T.A. (2000) *TIMSS 1999 international mathematics report: Findings from IEA's repeat of the third international mathematics and science study at the eighth grade*. Chestnut Hill, MA: Boston College.

Murphy, X. (2004) *An overview of Jamaica, the Island, and people*. Available at: https://jamaicans.com/fact/ (Accessed: 5 December 2020).

Mutch, C. (2005) *Doing educational research: a practitioner's guide to getting started. Wellington*. New Zealand: Council for Educational Research Press.

Myers, M. (2012) 'Lesson Study as a Means for facilitating preservice teacher reflectivity', *International Journal for the scholarship of Teaching and Learning*, 6(1). Available at: https://doi.org/10.20429/ijsotl.2012.060115 (Accessed: 13 July 2021).

Myllyntausta, S. (2012) 'What is good mathematics teaching?', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp 25-28.

Napaphun, V. (2012) 'Relational thinking: arithmetic in order to promote algebraic thinking', Journal of *Science and Mathematics Education in Southeast Asia*, 35(2), pp. 84–101. Available at http://recsam.edu.my/sub_JSMESEA/images/journals/YEAR2012/dec2012vol-2/84-101.pdf (Accessed: 25 June 2023).

National College for Teaching and Leadership (2015) *Subject knowledge enhancement: an introduction*. Available at: https://www.gov.uk/guidance/subject-knowledge-enhancement-anintroduction (Accessed: 30 January 2021).

National Council of Teachers of Mathematics (1989) *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics

National Council of Teachers of Mathematics (2000) *Principles and standards for school mathematics.* Reston: Virginia.

National Education Inspectorate (2013) *Chief inspector's report: promoting excellence through quality inspections.* Kingston, Jamaica: MoEC.

NCETM (2014) *Mastery approaches to mathematics and the new national curriculum* Available at https://www.ncetm.org.uk/media/2tlkwtz5/developing_mastery_in_mathematics_october_2014-pd.pdf (Accessed: 7 August 2018).

Nesmith, S. (2008) '*Mathematics and literature: educators', perspectives on utilizing a reformative approach to bridge two cultures*. Available at: https://files.eric.ed.gov/fulltext/EJ1099543.pdf (Accessed: 1 March 2019).

Nettleford, R. M. (1998). *Mirror, mirror: identity, race, and protest in Jamaica*. Kingston, Jamaica: Kingston Publishers Limited.

Nettleford, R. (2006) 'Cultural Studies: the way forward', in K. O. Hall (ed.), *Rex N: Selected speeches*. Kingston: Ian Randle Publishers, pp. 12–19.

Ng, S. and Rao, N. (2010) 'Chinese number words, culture, and mathematics learning', *Review of Educational Research*, 80(2), pp. 180–206. Available at https://www.jstor.org/stable/40658461
(Accessed 24 June 2023).

Nottingham, S. and Verscheure, S. (2010) 'The effectiveness of active and traditional teaching in the orthopedic assessment laboratory', *Journal of College Science Teaching,* 39(5), pp. 34-42.

Ntreh, N. (2020) *How Jamaica came to have its name*? Available at: https://face2faceafrica.com/article/how-jamaica-came-to-have-its-name (Accessed: 9 December 2020).

Nunan, D. (1999) *Research methods in language learning*. Cambridge: CUP Eighth printing.

Ogunyemi, O. O. (2010) *Wood's and Osborne Parnes' problem-solving models and students' learning outcome in junior secondary school social studies*. Master's thesis. Olabisi Onabanjo University, Ago- Iwoye.

Onwuegbuzie, A.J. and Johnson, R.B. (2006) 'The validity issue in mixed research', *Research in the Schools*, 13(1), pp.48-63.

Ormord, J.E. (1995) *Human learning*. Englewood Cliffs, NJ: Prentice Hall, Inc.

Overview of Jamaica (2020). Available at: https://jamaica55.gov.jm/in-a-nutshell-jamaica/overview-of-jamaica/ (Accessed: 11 December 2020).

Oxfam Digital Repository (no date) *An overview of the economy of Jamaica.* Available at: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/123007/bk-debt-poverty-jamaica-part-ii-010192-en.pdf;jsessionid=16B8CD7DE783850B1470F1445DD577AD?sequence=23
(Accessed: 26 September 2020).

Pajares, F., and Kranzler, J. (1995) 'Self-efficacy beliefs and general mental ability in mathematical problem-solving', *Contemporary Educational Psychology*, 20, pp. 426-443. Available at https://doi.org/10.1006/ceps.1995.1029 (Accessed: 4 July 2023).

Pallant, J. (2007) *SPSS survival manual: A step by step guide to data analysis using SPSS version 15*. 3rd edn. Maidenhead: Open University Press.

Palmer, D., Hermond, D. and Gardiner, C. (2014) 'Principals' leadership practices and mathematics pass rate in Jamaican high schools', *Administrative Issues Journal: Connecting Education, Practice and Research*, 4(2), pp. 35-47. Available at https://files.eric.ed.gov/fulltext/EJ1058511.pdf (Accessed: 13 March 2019)

Paris, D. (2012) ‘Culturally sustaining pedagogy: A needed change in stance, terminology, and practice’, *Educational Researcher*, 41(3), pp. 93-97. Available at: http:edr.sagepub.com/content/41/3/93 (Accessed: 2 June 2023).

Paris, D. (2021) ‘Culturally sustaining pedagogies and our Futures’, *The Educational Forum*, 85(4), pp. 364-376. Available at https://doi.org/10.1080/00131725.2021.1957634 (Accessed 5 June 2023).

Pelkola, T., Rasila, A. and Sangwin, C. (2018) ‘Investigating Bloom’s learning for mastery in mathematics with online assessment’, *Information in Education,* 17(2), pp. 363-380. Available at https://files.eric.ed.gov/fulltext/EJ1195654.pdf (Accessed: 4 August 2023).

Perveen, K. (2010) ‘Effect of the problem-solving approach on academic achievement of students in mathematics at the secondary level’, *Contemporary Issues in Education Research*, 3(3), pp. 9-14. Available at: https://files.eric.ed.gov/fulltext/EJ1072552.pdf (Accessed: 3 June 2020).

Phillips, D.C. and Soltis, J. F. (2009) *Perspectives on learning (Thinking about Education Series).* 5th edn. Teacher College Press.

Piggott, J. (2007) ‘The Nature of mathematical enrichment: a case study of implementation’, *Educate* 7(2), pp. 30-45. Available at: http://www.educatejournal.org/index.php/educate/article/view/110/140 (Accessed: 15 March, 2022).

Piggott, J. (2011a) *Mathematics enrichment: what it is and who it is for?* Available at: https://nrich.maths.org/5737 (Accessed: 21 November 2020).

Piggott, J. (2011b) *Developing a framework for mathematical enrichment*. Available at: https://nrich.maths.org/5741 (Accessed: 18 January 2021).

Piggott, J. and Black, J (2011) ‘Enrichment at NRICH’, *Primary Mathematics*, 8(1), Leicester: Mathematical Association, Spring 2004. Available at: https://nrich.maths.org/5740 (Accessed: 18 January 2021).

Pintrich, P.R. and De Groot, E.V. (1990) ‘Motivational and self-regulated learning components of classroom academic performance’, *Journal of educational psychology*, *82*(1), p. 33.

Pitman, P. (2012) ‘Successful implementation of changes in practice: enhancing the teaching and learning of maths at Grouville School’, in D. Burghes (ed.) *Enhancing Primary Mathematics Teaching and Learning*. CfBT Education Trust, pp. 46-49.

Planning Institute of Jamaica (2009) *Vision 2030 Jamaica: national development plan.* Available at: https://sustainabledevelopment.un.org/content/documents/1501jamaica.pdf (Accessed: 12 September 2018)

Polya, G. (1971) *How to solve it. Princeton*. NJ: Princeton University Press.

Pope, S. (2010). The opportunities of the revised secondary national curriculum in England for using the history of mathematics. Available at: https://jstor.org/stable/20799086 . (Accessed January 13, 2021).

Powell, P. A. (2022) *Resisting and reproducing colonialism in contemporary Jamaican education: an autoethnography and narrative inquiry*. PhD Thesis. Barry University. Available at https://www.proquest.com/openview/ad43aca1b60c49f47c378e054e58e1b5/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y (Accessed: 12 June 2023).

Raja, R. and Mythily, P. (2018) 'Curriculum enrichment in higher education', *Curriculum enrichment in higher education*. Salem: Tamilnadu Available at: https://www.researchgate.net/publication/327963644_CURRICULUM_ENRICHMENT_IN_HIGHER_EDUCATION (Accessed: 14 March 2021).

Rea, L. M., & Parker, R. A. (1997) *Designing and conducting survey research: a comprehensive guide.* San Francisco, CA: Josey-Bass Publishers.

Reynolds, A. (1992) 'What is competent beginning teacher? A review of the literature', *Review of Educational Research*, 62(1), pp. 1-35.

Riordan, J., and Noyce, P. (2001) 'The impact of two standards-based mathematics curricula on student achievement in Massachusetts', *Journal for Research in Mathematics Education*, 28(4), pp. 368-398.

Robinson, D. (2012) 'Moving forward with lesson study', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. CfBT Education Trust, pp 39-45.

Robson, C. (1993) *Real world research*, a resource for social scientists and practitioner researchers. Oxford: Blackwell Publishers Inc.

Rowland, T., Turner, F., Thwaites, A., and Huckstep, P. (2009) *Developing primary mathematics teaching: reflecting on practice with the knowledge quartet*. London: SAGE Publications Ltd.

Ruppert, N.B. *et al.* (2022) 'Culturally sustaining practices for middle level mathematics teachers', *Education Sciences*, 12(12), p. 910. doi:10.3390/educsci12120910.

Santos, S. and Barmby, P. (2016) *Enrichment and engagement in mathematics* Available at: https://bsrlm.org.uk/wp-content/uploads/2016/02/BSRLM-IP-30-1-26.pdf (Assessed: 23 January 2022).

Satchwell, R.E. and Loepp, F.L. (2002) 'Designing and implementing an integrated mathematics, science and technology curriculum for middle school', *Journal of Industrial Education,* 39(3). Available at: https://scholar.lib.vt.edu/ejournals/JITE/v39n3/satchwell.html (Accessed: 12 December 2020).

Schacter, J. (2001) *Reducing social inequality in elementary school reading achievement: establishing summer literacy day camps for disadvantaged children.* Santa Monica, CA: Milken Family Foundation.

Schiever, S. W., Maker, C. J. (2003) 'New directions in enrichment and acceleration', in N. Colangelo and G.A. Davis. (eds.) *Handbook of gifted education*. Boston, MA: Allyn & Bacon, pp. 163-173

Schifter, D., and Fosnot, C. T. (1993) *Reconstructing mathematics education: stories of teachers meeting the challenge of reform*. New York: Teachers College Press.

Schnell, S. and Prediger, S. (2016) 'Mathematics enrichment for all-noticing and enhancing mathematical potentials of underprivileged students as an issue of equity', *EURASIA Journal of Mathematics Science and Technology Education*, ISSN 1305-8223. Available at: https://pdfs.semanticscholar.org/7a21/81e29229249f779389be8b5031a3c94e02b0.pdf (Accessed: 24 December 2020).

Schoonenboom, J. and Johnson, R. B. (2017) 'How to construct a mixed methods research design', *Kolner Zeitschrift fur Soziologie und Sozialpsychologie*, *69*(2), pp. 107–131. Available at: https://doi.org/10.1007/s11577-017-0454-1 (Accessed: 12: June 2019).

Schukajlow, S., Rakoczy, K. and Pekrun, R. (2023) 'Emotions and motivation in mathematics education: where we are today and where we need to go', *ZDM Mathematics Education*, 55, pp. 249-267. Available at https://doi.org/10.1007/s11858-022-01463-2 (Accessed: 28 July 2023)

Sebba, M. (2014) *London Jamaican: Language system in Interaction*. London: Routledge.

Sechrest, L., and Sidani, S. (1995) 'Quantitative and qualitative methods: Is There an Alternative?', *Evaluation and program planning, 18*(1), pp. 77-87.

Shulman, L.S. (1986) 'Those who understand: Knowledge growth in teaching', *Educational Researcher*', 15(2), pp. 4-14. Available at: https://www.wcu.edu/webfiles/pdfs/shulman.pdf (Accessed: 14 December 2020).

Shulman, L., (1987) 'Knowledge and teaching: Foundations of the new reform', *Harvard educational review*, *57*(1), pp.1-23.

Sieber, S. D. (1973) 'The integration of fieldwork and survey methods', *American journal of sociology*, 78(6), pp. 1335-1359. Available at: http://www.dww.cz/docs/integration_of_fieldwork.pdf (Accessed: 21 February 2020).

Siyepu, S. (2013) 'The zone of proximal development in the learning of mathematics', *South African Journal of Education*, 33(2), pp. 1-13. Available at https://files.eric.ed.gov/fulltext/EJ1136052.pdf (Accessed: 27 June 2023).

Skemp, R. R. (1961) 'Reflective intelligence and mathematics', *The British Journal of Educational Psychology*, 31, pp. 45-55.

Skemp, R. R (1978) 'Relational Understanding and Instrumental Understanding', *The Arithmetic Teacher*, 26(3), pp. 9–15. Available at https://teamone.msuurbanstem.org/wp-content/uploads/2014/07/Skemp-Relational-Instrumental-clean-copy-AT-1978.pdf (Accessed: 26 June 2023).

Skemp, R. R. (1979). *Intelligence, Learning and Action: A Foundation for Theory and Practice in Education,* Chichester, UK: Wiley

Skemp, R. R. (1985). PMP: A progress report, *Proceedings of the 9th Conference of the International Group for the Psychology of Mathematics Education*, Utrecht Netherlands, 447–452.

Skemp, R. (1989) *Mathematics in the Primary School.* London: England: Routledge.

Skinner, B.F. (1971). *Beyond freedom and dignity*. Reprint. Indianapolis, Indiana: Hackett, 2002. Available at https://play.google.com/books/reader?id=78pgDwAAQBAJ&pg=GBS.PP3&printsec=frontcover&source=gbs_atb (Accessed: 12 July 2021).

Smart, A. S. (2011) 'Designing and teaching an elementary school enrichment program: what the students were taught and what I learned', *The Mathematics Enthusiast* 8(1), pp. 227-244. Available at: http://scholarworks.umt.edu/tme/vol8/iss1/12 (Accessed: 14 March 2022).

Smith, A. (2018) *Government focused on boosting public-private partnerships*. Available at: https://jis.gov.jm/government-focused-on-boosting-public-private-partnerships/ (Accessed: 8 October 2020).

Smith, J.P., III. (1996) 'Efficacy and teaching mathematics by telling: a challenge for reform', *Journal for Research in Mathematics Education* 27(4), pp. 387-402.

Smith, R. (2012) 'The role of the mathematics co-ordinator', in D. Burghes (ed.) *Enhancing primary mathematics teaching and learning*. Berkshire, New York: CfBT Education Trust, pp. 50-62.

Sonis, R. (2004) *Jamaica: The true Culture.* Available at https://digitalcommons.wou.edu/cgi/viewcontent.cgi?article=1334&context=his (Accessed: 23 June 2023)

Spelke, E. (2000) 'Core knowledge", American *Psychologist,* 55(11), pp.1233-1243. Available at: https://psycnet.apa.org/doi/10.1037/0003-066X.55.11.1233 (Accessed: 3 January 2020).

Stevenson, M. (2008) 'Profound understanding of fundamental mathematics: a study into aspects of the development of a curriculum for content and pedagogical subject knowledge', *Proceedings of the British Society for Research into Learning Mathematics*, 28(2), pp. 103-107. Available at: https://bsrlm.org.uk/wp-content/uploads/2016/02/BSRLM-IP-28-2-18.pdf (Accessed: 18 January 2020).

Stewart, S. (2013) *Everything in the di dark muss come to light: a postcolonial investigation of the practice of extra lessons at the secondary level in Jamaica's* *education system.* Phd Thesis. University of Denver. Available at https://digitalcommons.du.edu/cgi/viewcontent.cgi?article=1999&context=etd (Accessed: 20 July 2023).

Stripp, C. (2014) *Mastery in mathematics: what it is and why we should be doing* it. Available at https://www.ncetm.org.uk/features/mastery-in-mathematics-what-it-is-and-why-we-should-be-doing-it/ (Accessed: 7 August 2023).

Swan, M. (2008) 'A designer speaks: designing a multiple representation learning experience in secondary algebra', *Educational Designer,* 1(1). Available at: www.educationaldesigner.org/ed/volume1/issue1/article3 (Accessed: 27 March 2020).

Swetz, F. J. (2009) 'Culture and the development of mathematics: an historical perspective', in B. Greer, S. Mukhopadhyay, A. Powell, and S. Nelson-Barber (eds.) *Culturally responsive mathematics education*. New York, NY: Routledge pp. 11–41.

Takahashi, A. (2014) 'Supporting the effective implementation of a new mathematics curriculum: a case study of school-based lesson study at a Japanese public elementary school', in I.Y. Li and G. Lappan (eds) *Mathematics curriculum in school education*. Dordrecht, The Netherlands: Springer, pp. 417–442.

Takahashi, A., Watanabe, T. and Yoshida, M. (2006) *Developing good mathematics teaching practice through lesson study: A US perspective*. Available at: http://www.apecneted.org/resources/downloads/Takahashi.pdf (Accessed: 6 January 2019).

Tall, D. (2008) 'Using Japanese lesson study in teaching mathematics', *Scottish Mathematical Council Journal*, 38, pp. 45-50.

Taylor, W. (2019) *Enrichment in the classroom.* Available at: https://learningessentialsedu.com/enrichment-in-the-classroom/ (Accessed: 15 June 2020).

Teddlie, C. and A. Tashakkori (2009) *Foundations of mixed methods research*. Thousand Oaks, CA: Sage Publications

Tepylo, D. H., and Moss, J. (2011) 'Examining change in teacher mathematical knowledge through lesson study', in Hart, L.C., Alston, A.S. and Murata, A. (eds) *Lesson study research and practice in mathematics education*. Dordrecht: Springer, pp. 59-78

The Primary ATM/MA and 11-16 MA Sub-Committess (2012) *Enrichment ideas and resources for primary and secondary mathematics.* Available at: https://www.m-a.org.uk/pdf/Enrichment_Ideas_and_Resources.pdf (Accessed: 22 February 2019).

The world bank in Jamaica (2020). Available at: https://www.worldbank.org/en/country/jamaica/overview#1 (Accessed: 27 March 2021).

Thomas, L. (2022) *Quasi-experimental design | definitions, types & examples*. Available at https://www.scribbr.com/methodology/quasi-experimental-design/ (Accessed: 8 August 2022).

Tobias, J. M. (2020) 'The evolution of classroom structure', *NCTM,* 113(2), pp. 170-171. Available at: https://pubs.nctm.org/view/journals/mtlt/113/2/article-p170.xml?tab_body=fullHtml (Accessed: 30 December 2020).

Trines, S. (2019) *Education in Jamaica*. Available at: https://wenr.wes.org/2019/09/education-in-jamaica (Accessed: 23 December 2020).

Tuleram, G. and Machisella, P. (2018) 'Traditional vs non-traditional teaching and learning strategies – the case of E-learning!', *International Journal for Mathematics Teaching and Learning*, 19(1) pp. 129-158. Available at: https://www.cimt.org.uk/ijmtl/index.php/IJMTL/article/view/21 (Accessed: 30 December 2020).

Tyson, E. (2012) *Education then and now*. Available at: http://jamaica-gleaner.com/gleaner/20120805/cleisure/cleisure4.html (Accessed: 23 December 2020).

Van De Walle, J. A. (2007) *Elementary and middle school mathematics: Teaching developmentally*. 6th edn. Boston, MA: Pearson Education, Inc.

Van Trotsenburg, A. (2019) 'Jamaica has made an "extraordinary" economic turnaround. Miami Herald', *The World Bank*. Available at https://www.worldbank.org/en/news/opinion/2019/05/16/jamaica-has-made-an-extraordinary-economic-turnaround (Accessed: 2 September 2020)

Venkatesh, V., Brown, S.A. and Bala, H. (2013) 'Bridging the qualitative-quantitative divide: guidelines for conducting mixed methods research in information systems', *MIS Quarterly, 37*(1), pp. 21-54. Available at: https://misq.umn.edu/bridging-the-qualitative-quantitative-divide-guidelines-for-conducting-mixed-methods-research-in-information-systems.html (Accessed: 12 February 2020).

Venkatesh, V., Brown, S.A., and Sullivan, Y.W. (2016) 'Guidelines for conducting mixed-methods research: an extension and illustration', *Journal of the Association for Information Systems,* 17(7), pp. 435-495. Available at: http://dx.doi.org/10.17705/1jais.00433 (Accessed: 3 June 2020).

Vygotsky, L.S. (1978) *Mind and society: the development of higher mental processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1986) *Thought and language*, Rev. edn. Edited by A. Kozulin. Cambridge, MA: MIT Press.

Waite, R. (2000) *A study of the effects of everyday mathematics on student achievement of third-, fourth, and fifth-grade students in a large north Texas urban school district*. PhD Thesis, *UMI No. 9992659*. University of Texas.

Wang-Iverson, P. and Yoshida, M. (2005) *Building our understanding of lesson study*. Philadelphia, Penn: Research for Better Schools.

Watson, A. (2008) 'School mathematics as a special kind of mathematics', *For the Learning of Mathematics*, 28(3), pp. 3–7. Available at: https://flm-journal.org/Articles/flm_28-3_Watson.pdf (Accessed: 13 July 2020).

Wen, P. (2018) 'Application of Bruner's learning theory in mathematics studies', *Proceedings of the international conference of contemporary education, social sciences and ecological Studies (CESSES)*. Moscow, 29-30 March. Available at https://doi.org/10.2991/cesses-18.2018.53 (Accessed: 5 August 2023).

Wiggins, H., Harding, A. and Engelbrecht, J. (2017) 'Student enrichment in mathematics: a case study with first year university students', *International Journal of Mathematical Education in Science and Technology*, 48(sup1), pp. S16-S29. Available at: https://doi.org/10.1080/0020739X.2017.1352046 (Accessed: 7 May 2020).

Williams, C. (2008) 'Realising rights through social guarantees: the case of Jamaica', Final Report submitted to the World Bank. Available at: http://siteresources.worldbank.org/EXTSOCIALDEV/Resourc es/317739-1168615404141/3328201-1192042053459/Jamaica.pdf (Accessed: 14 June 2019).

Williams, D. (2018) *Jamaican folk music: rich flavored beats to the rhythmic tunes.* Available at https://www.jamaica-reggae-music-vacation.com/Jamaican-Folk-Music.html (Accessed: 1 July 2023).

Williams, R. N. (2022) *Investigating culturally responsive teaching in the Jamaican music classroom: a multiple case study.* Phd Thesis. Boston University. Available at https://open.bu.edu/ds2/stream/?#/documents/422957/page/1 (Accessed: 10 June 2023).

Wilson, A. (2004) *Jamaica the culture.* New York: Crabtree Publishing Company. Available at https://books.google.com/books?id=MlwIvXK5XQQC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false (Accessed: 30 June 2023).

Wilson, S., Shulman, L., and Richert, A. (1987) '150 different ways of knowing: representations of knowledge in teaching', in J. Calderhead (ed) *Exploring Teachers' Thinking,* Eastbourne, UK: Cassell pp. 104-123.

Winget, M. and Persky, A. M. (2022) 'A Practical review of mastery learning', *American Journal of Pharmaceutical Education*, 86(10), pp. 1114-1122

Wood, R. (2014) *Sport in Jamaica*. Available at: https://www.topendsports.com/world/countries/jamaica.htm (Accessed: 29 March 2021).

World Music Network (2013) *The music of Jamaica: from roots to ragga*. Available at: https://worldmusic.net/blogs/guide-to-world-music/the-music-of-jamaica-from-roots-to-ragga
(Accessed: 30 March 2021).

Yeo, K. K. J (2009) 'Students' difficulties solving non-routine problems', *International Journal of Mathematics Teaching and Learning*. ISSN-1473-0111.

Young, P. (2014) 'The presence of culture in learning', in Spector, J.M., Merrill, M.D., Elen, J. and Bishop, M.J. (eds.) *Handbook of research on educational communications and technologies,* 4th edn, pp. 349-361. Available at: https://www.researchgate.net/publication/290022626_The_Presence_of_Culture_in_Learning (Accessed: 14 June 2023).

Zan, R., Brown, L., Evans, J., & Hannula, M. S. (2006). Affect in mathematics education: an introduction. *Educational Studies in Mathematics, 63*, 113-121. https://doi.org/10.1007/s10649-006-9028-2

Zohrabi, M. (2013) 'Mixed method research: instruments, validity, reliability and reporting findings', *Theory and Practice in Language Studies*, 3(2), pp. 254-262. Available at: http://www.academypublication.com/issues/past/tpls/vol03/02/06.pdf (Accessed: 4 January 2022).

APPENDICES

APPENDIX A: PARTICIPANTS INFORMATION SHEET

Project:
Evaluating the Integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes

Project Contact details:
Name of Student: Shandelene Binns-Thompson
Contact Details: shandelene.binns-thompson@plymouth.ac.uk
Name of Director of Studies: Professor David Burghes
Contact Information: david.burghes@plymouth.ac.uk
Name of Supervisor: Professor Garry Hornby
Contact Information: garry.hornby@plymouth.ac.uk

Description of Project:
The aim of this project is to investigate the impact of integrating a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The Mathematics Enhancement Programme focuses on building a strong mathematical foundation for learners based on evidence of good practices from mathematically high performing countries. The MEP was developed by the Centre for Innovation in Mathematics Teaching (CIMT) at Plymouth University and is currently being implemented with successful outcomes in UK schools. In light of this, this project will seek to adopt and tailor aspects of the MEP to the Jamaican context, since both countries have a similar mathematics curriculum.

The participants for this research will be divided into two groups; an intervention group and a comparison group. The intervention group will consist of 400 students and 12 teachers from four Primary schools across Jamaica while the comparison group will consist of 120 students and four teachers from two different Primary Schools in Jamaica. Only the participants of the intervention group will be exposed to the intervention. The intervention will involve aspects of the MEP that will be adapted and used by the intervention group. The intervention will involve the use of direct interactive teaching, pupil discussion, explanation, demonstrations, use of resources and suggested lesson plans

Data will be collected over a two year period starting April 2018. The method of collection will involve classroom observations, interviews, children's mathematics attitudinal survey and pre and post testing. The data collected will be analysed by the researcher to evaluate the impact the integration of the MEP has on primary mathematics education in Jamaica.

What you will have to do if you agree to part take?
As a participant of the intervention group of this research you will be required to:

- grant access to your grades one and two mathematics classes
- integrate the MEP in grades one and two mathematics classes over a two year period
- permit classroom observations by researcher

- provide answers to interview questions (answering interview questions is voluntary)
- assist in arranging the focus group interviews with pupils
- allow researcher to administer pre-tests and post-tests to participating pupils
- be engaged in continuing professional development sessions associated with the MEP

As a participant of the comparison group of this research you will be required to:

- allow the researcher to administer pre-tests and post-tests to participating pupils

Informed Consent
Your decision to participate in this project is voluntary. It is up to you whether you wish to participate or not. You will also be required to read and sign an Informed Consent Form.

Right to withdraw
As a participant you have the right to withdraw from this project at any given time, up until the end of the data collection process. Data collection associated with this project will end December 20, 2019. Your involvement in this project is voluntary and you are **NOT** subjected to:

- answer any question being posted,
- and you may withdraw from the project at any time

Advantages and Disadvantages of Participating in Project:
As a participant, you may find the project to be resourceful, informative, interesting and relevant. Upon completion, this research will provide information about the impact of integrating MEP in Jamaican Mathematics Classes.
The information obtained from this project will prove significant in allowing Jamaican Mathematics Policy Makers in the Educational System to become aware of some best practices of high performing countries in Mathematics. It will also be instrumental in helping teachers of mathematics to adopt and tailor key effective practices in Mathematics Education to help in catering for the needs of their students.
You may decide not to participate in this research if you are not comfortable with granting access to your students' current competency levels in Mathematics and not wanting to be the first to be exposed to this kind of intervention in the Island of Jamaica.

Debriefing
As a participant, you will be given the opportunity to learn about the outcomes of the research by December 2020. You may however, obtain information on the progress of the research and request copies of outputs at any given time.

Confidentiality
All data collected during this research will be kept strictly confidential and will **ONLY** be used for the purposes of the research identified above. Your identity and the identity of your institution, educators and pupils will remain anonymous throughout and after the research project. Your responses will be anonymised.

Planned Outputs
The results of the study will help the researcher to measure the impact the integration of the Mathematics Enhancement Programme has on mathematics education in Jamaica. It is also hoped that the results of this research project will help in reforming mathematics education in Jamaica and subsequently improve performance in the discipline.

Data Storage
In keeping with Plymouth University's ethics policy, the data obtained from this research will be stored for a minimum of ten years after the completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and or discs will be encrypted. Hard copies of the data will be stored in locked filing cabinets and disposed of securely when no longer required.

Feedback
If you have further questions related to this study, please contact Shandelene Binns-Thompson at (876)430-4873 or at shandelene.binns-thompson@plymouth.ac.uk

APPENDIX B: INFORMED CONSENT FORM

Project:
Evaluating the Integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes

Project Contact details:
Name of Student: Shandelene BinnsThompson
Contact Details: shandelene.binns-thompson@plymouth.ac.uk
Name of Director of Studies: Professor David Burghes
Contact Information: david.burghes@plymouth.ac.uk
Name of Supervisor: Professor Garry Hornby
Contact Information: garry.hornby@plymouth.ac.uk

Please confirm the following statements, by ticking selecting 'yes I confirm' or 'no I do not confirm'.

Statements	**Yes I Confirm**	**No I do not Confirm**
• I voluntarily agree to participate in the project		
• I was given a chance to ask questions about the project.		
• My role as a participant in this project was fully explained to me		
• I understand that I can withdraw from participating from the project at anytime, up until the end of the data collection process (December 20, 2019) without being penalized or questioned.		
• Procedures regarding confidentiality have been fully explained to me		
• Consent for pre and post testing, interviews, classroom observations have been explained and provided to me		
• The use of the data in research publication, sharing and archiving has been explained to me.		
• It has been explained that all data collected from me will be anonymized for research publication, sharing and archiving.		

I, along with the Researcher, agree and sign and date this informed consent form

Participant

____________________ ______________________ _____________
Participants' Name. Signature. Date

Researcher

_________________________ ______________________ _____________
Shandelene Binns Thompson Signature Date

APPENDIX C: PROJECT EXPLANATION FOR CHILDREN

The project will be explained to children in the presence of their teachers and possible parents (depending on their availability). It will be explained to them in the comforts of their classrooms using simple age-appropriate classroom. Visual aids (books and MEP supporting manipulative) will be used where necessary. The researcher will also seek to engage children in this discussion about the project by allowing them to ask questions and asking them simple questions related to mathematics.

The project will be explained to the children as follows:

> *The Mathematics Enhancement Programme (MEP) is a new way of teaching mathematics.*
> *The MEP was started in England. The programme was made to help children to better understand mathematics. The MEP also helps children to make progress in mathematics.*
> *Your teachers want to start teaching you mathematics the MEP way. Each of you will receive MEP books, number lines, number grids and counters to use in your mathematics classes. Learning Mathematics the MEP way is Fun.*

APPENDIX D: CONSENT LETTERS

Appendix D – 1: School Administrators Consent Letter (Intervention Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

I am hereby soliciting your permission, as principal of this noble institution, to engage your grade one and subsequently grade two teachers and students in this research project as participants of the intervention group. Please respond in writing on or before March 31, 2018 your willingness to allow representatives from your institution to participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

Yours truly,

Shandelene Binns -Thompson (Mrs.)

Appendix D – 2: School Administrators Consent Letter (Comparison Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

I am hereby soliciting your permission, as principal of this noble institution, to engage your grade one and subsequently grade two teachers and students in this research project as participants of the comparison group. Please respond in writing on or before March 31, 2018 your willingness to allow representatives from your institution to participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

Yours truly,

Shandelene Binns -Thompson (Mrs.)

Appendix D-3: Teachers' Consent Letter (Intervention Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

I am hereby seeking your permission, as class teacher of grades one or two for you and your students to participate in this research as part of the intervention group. Please respond in writing on or before March 31, 2018 your willingness to participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

Yours truly,

Shandelene Binns -Thompson (Mrs.)

Appendix D – 4: Teachers' Consent Letter (Comparison Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

I am hereby seeking your permission, as class teacher of grades one or two for you and your students to participate in this research as part of the comparison group. Please respond in writing on or before March 31, 2018 your willingness to participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

Yours truly,

Shandelene Binns -Thompson (Mrs.)

Appendix D – 5: Parents' Consent Letter (Intervention Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

Your child/ward is part of one of the class selected to participate in the intervention group of this study. I am hereby requesting your permission in allowing your child/ward to be a part of this investigation. Please respond in writing on or before March 31, 2018 your willingness to allow your child/ward participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

Yours truly,

Shandelene Binns -Thompson (Mrs.)

Appendix D – 6: Parents' Consent Letter (Comparison Group)

Christiana P.O.
Manchester
Jamaica, W.I.

Date

To Whom It May Concern

Dear Sirs,

I am Shandelene Binns-Thompson, a MPhil/PhD student at Plymouth University, Drakes Circle Plymouth Devon PL4 8AA. As part of the partial fulfilment of the MPhil/PhD Programme, I am expected to complete a research project. My research is focusing on evaluating the integration of a Mathematics Enhancement Programme (MEP) into Jamaican Primary Mathematics Classes. The research project will be employing an embedded quasi-experimental mixed-method research design. This means that the data for this study will be collected both quantitatively and qualitatively from the intervention and comparison groups. The participants of the intervention group for this research will consist of approximately 400 students and 12 teachers from three Primary schools across Jamaica and the comparison group will consist of approximately 200 students and seven teachers from two different Primary Schools in Jamaica. Please see the attached information sheet and Informed consent form for more information.

Your child/ward is part of one of the class selected to participate in the comparison group of this study. I am hereby requesting your permission in allowing your child/ward to be a part of this investigation. Please respond in writing on or before March 31, 2018 your willingness to allow your child/ward participate in this research project. Data collection associated with the intervention will last for approximately two year and will commence April 2018.

Thanks for your cooperation.

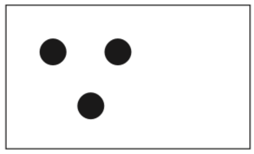
Yours truly,

Shandelene Binns -Thompson (Mrs.)

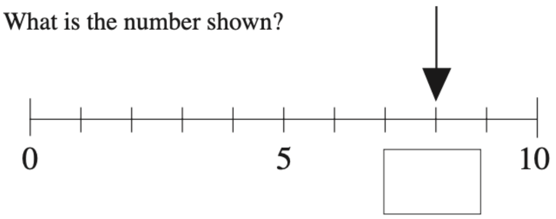
APPENDIX E: PRE-TESTS AND POST-TESTS

TEST 0

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



3. Fill in the missing numbers.

(a) $2 + 3 = \square$ (b) $4 - 1 = \square$

(c) $3 + 4 = \square$ (d) $4 + \square = 9$

(e) $8 - \square = 3$ (f) $\square + 7 = 7$

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

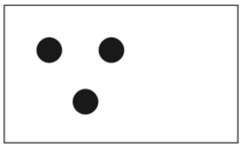
. . . .

(b) Circle all the **odd** numbers.

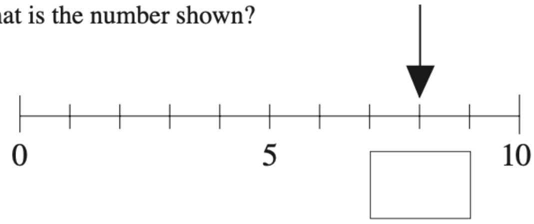
CIMT / MEP / IPMA / September 1998

TEST 1

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



3. Fill in the missing numbers.

(a) $2 + 3 = \square$

(b) $4 - 1 = \square$

(c) $3 + 4 = \square$

(d) $4 + \square = 9$

(e) $8 - \square = 3$

(f) $\square + 7 = 7$

4. (a) Write these numbers in order of increasing size.

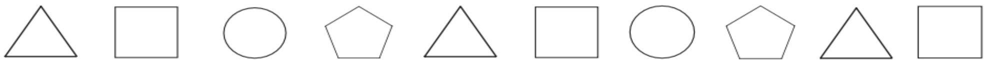
12, 7, 15, 4, 1, 10, 18

. . . .

(b) Circle all the **odd** numbers.

Test 1

5.

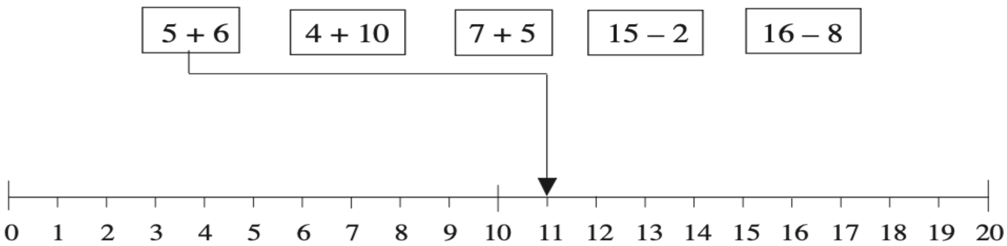


(a) Write the letter A on the third shape from the left.

(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

6. Show with an arrow the answer to each sum. The first one has been done.



7. What is the next number?

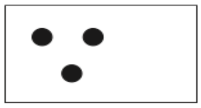
(a) 3, 6, 9, 12, ☐

(b) 20, 18, 16, 14, ☐

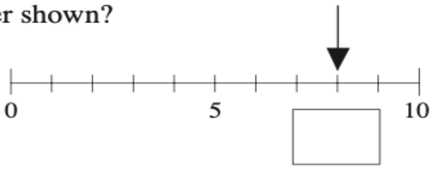
(c) 2, 6, 10, 14, ☐

TEST 2

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



3. Fill in the missing numbers.

(a) $2 + 3 = \square$ (b) $4 - 1 = \square$

(c) $3 + 4 = \square$ (d) $4 + \square = 9$

(e) $8 - \square = 3$ (f) $\square + 7 = 7$

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

. . . .

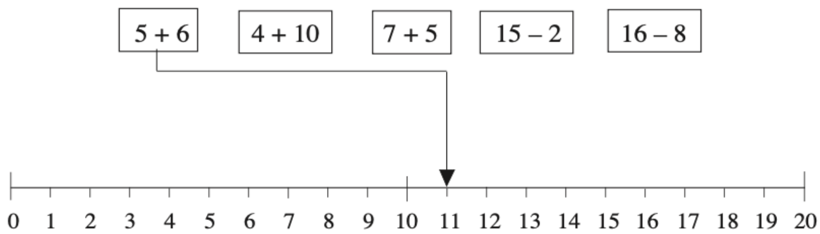
(b) Circle all the **odd** numbers.

5. 

(a) Write the letter A on the third shape from the left.
(b) Write the letter B on the fourth shape from the right.
(c) Write the letter T on any triangle.

Test 2

6. Show with an arrow the answer to each sum. The first one has been done.

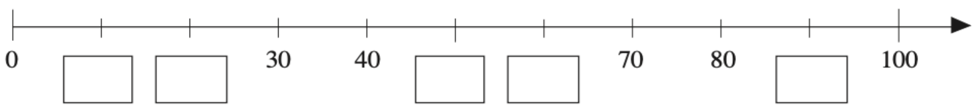


7. What is the next number?

(a) 3, 6, 9, 12, $\boxed{}$ (b) 20, 18, 16, 14, $\boxed{}$

(c) 2, 6, 10, 14, $\boxed{}$

8. Fill in the missing numbers on the number line.



9. Fill in the missing numbers.

(a) $27 + 12 = \boxed{}$ (b) $35 - 3 = \boxed{}$

(c) $15 + 17 = \boxed{}$ (d) $46 - 18 = \boxed{}$

(e) $73 + \boxed{} = 99$ (f) $43 - \boxed{} = 27$

Test 2

10. Fill in the missing numbers.

(a) $8 \times 2 = \square$ (b) $14 \div 2 = \square$

(c) $15 \div \square = 3$ (d) $6 \times \square = 18$

11. Fill in the missing numbers.

(a) 31, 37, 43, $\square$, $\square$

(b) $\square$, 12, 19, 26, $\square$

(c) 3, 9, 27, $\square$

12. Mary buys two sweets costing 20 cents and 23 cents.
What is her change from 50 cents?

13. Colour the weights which together make exactly 17 kg.

5 kg 7 kg 4 kg 3 kg 2 kg 2 kg

14. Tickets cost $4 each. How many can be bought for $15?

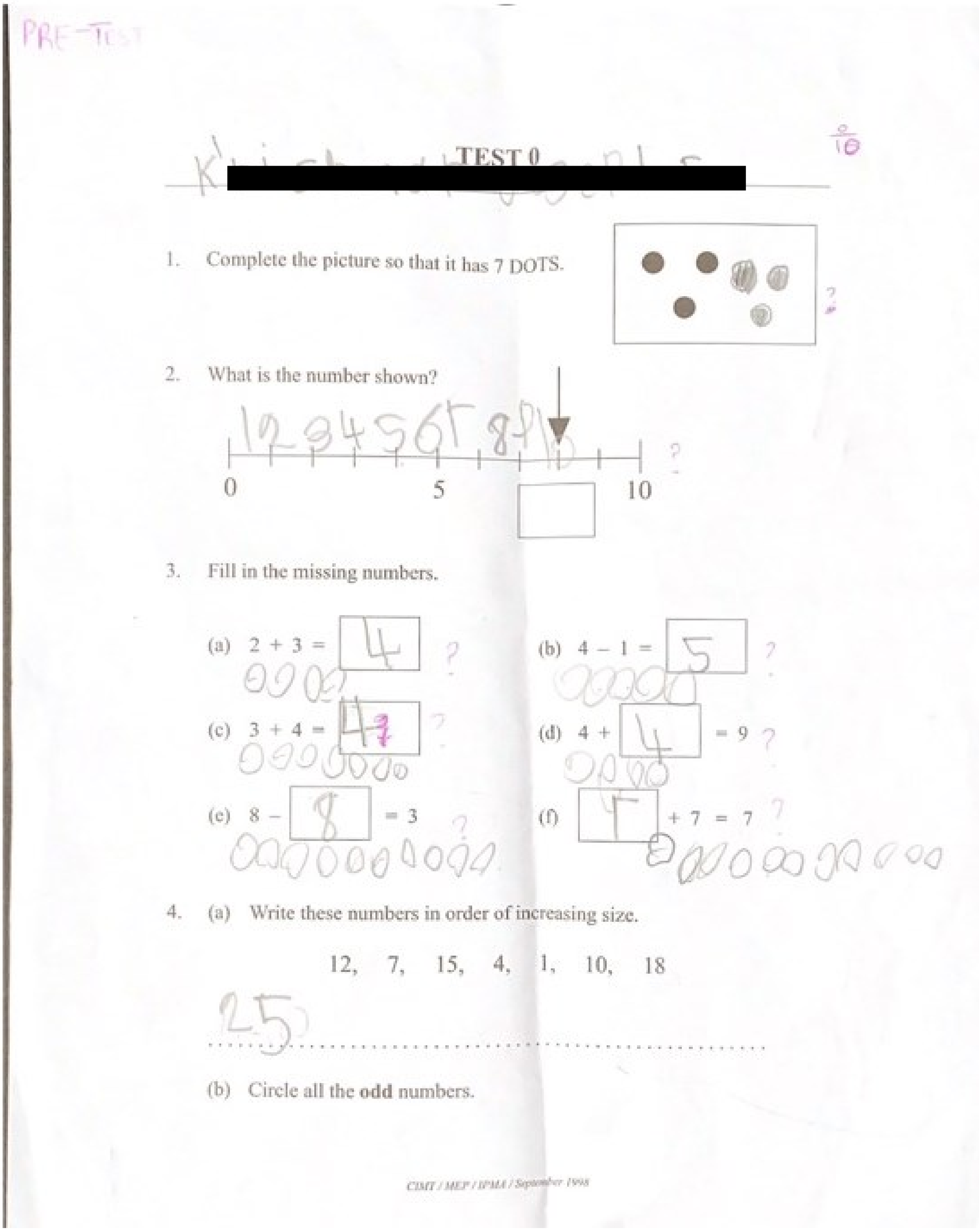
15. 20 cards are shared out equally among 5 children.
How many cards does each child have?

16. Colour in a quarter of the total number of circles.

17. Peter thinks of a number. He multiplies it by 3, takes away 2 and gets 25. What was his number?

APPENDIX F: SAMPLE PRE- AND POST-TESTS

Appendix F-1: Sample Pre-Test Scripts for the Grade One Participants


PRE-TEST

TEST 0

[redacted]

0/10

1. Complete the picture so that it has 7 DOTS. ?

2. What is the number shown? ?

0 5 10

3. Fill in the missing numbers.

(a) 2 + 3 = 4 ? (b) 4 − 1 = 5 ?

(c) 3 + 4 = 4 7 ? (d) 4 + 4 = 9 ?

(e) 8 − 8 = 3 ? (f) 5 + 7 = 7 ?

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

25

(b) Circle all the **odd** numbers.

CIMT / MEP / IPMA / September 1998

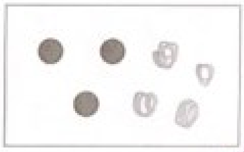
PRE-TEST

TEST 0

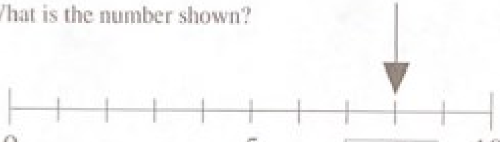
[redacted]

4/10

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



6 ?

3. Fill in the missing numbers.

(a) 2 + 3 = 5

(b) 4 − 1 = 5 ?

(c) 3 + 4 = 7

(d) 4 + 5 = 9

(e) 8 − 11 = 3 ?

(f) 7 + 7 = 7 ?

4. (a) Write these numbers in order of increasing size.

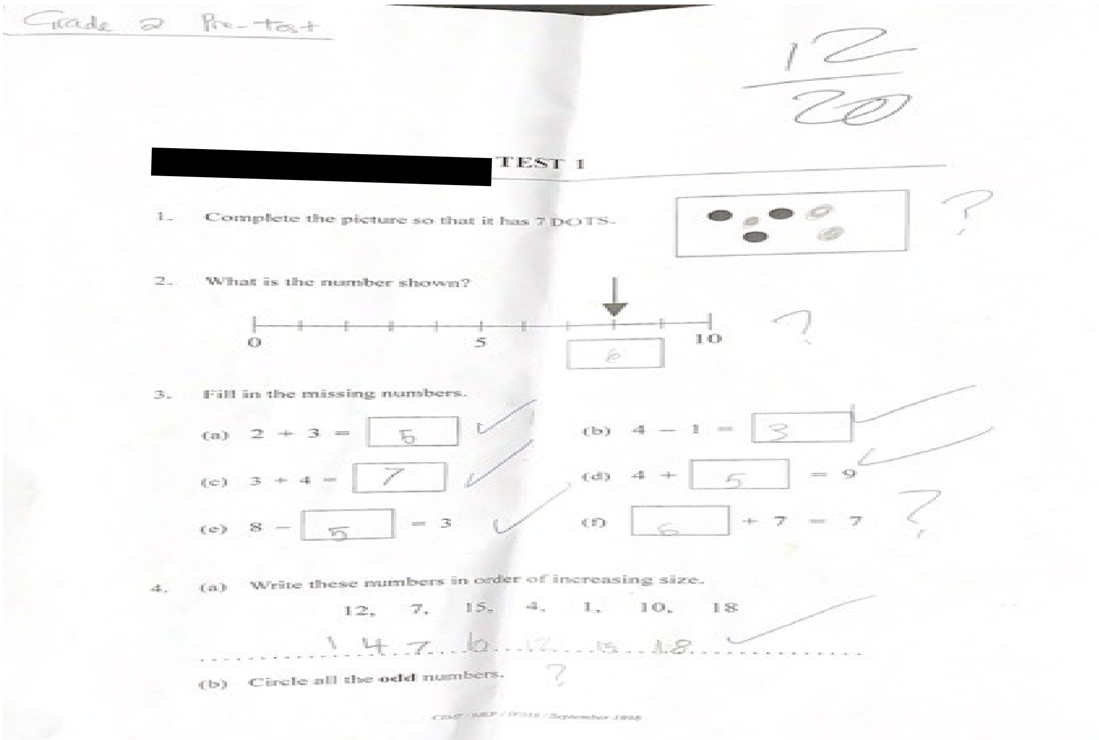
12, 7, 15, 4, 1, 10, 18

12 7 7 15 4 1 10 18 15 ?

(b) Circle all the **odd** numbers.

CIMT / MEP / IPMA / September 1998

Appendix F – 2: Sample Pre-Test Scripts for the Grade Two Participant



Grade 2 Pre-test

12/20

[redacted] TEST 1

1. Complete the picture so that it has 7 DOTS. ?

2. What is the number shown?

0 5 10

6 ?

3. Fill in the missing numbers.

(a) 2 + 3 = 5 (b) 4 − 1 = 3

(c) 3 + 4 = 7 (d) 4 + 5 = 9

(e) 8 − 5 = 3 (f) 6 + 7 = 7 ?

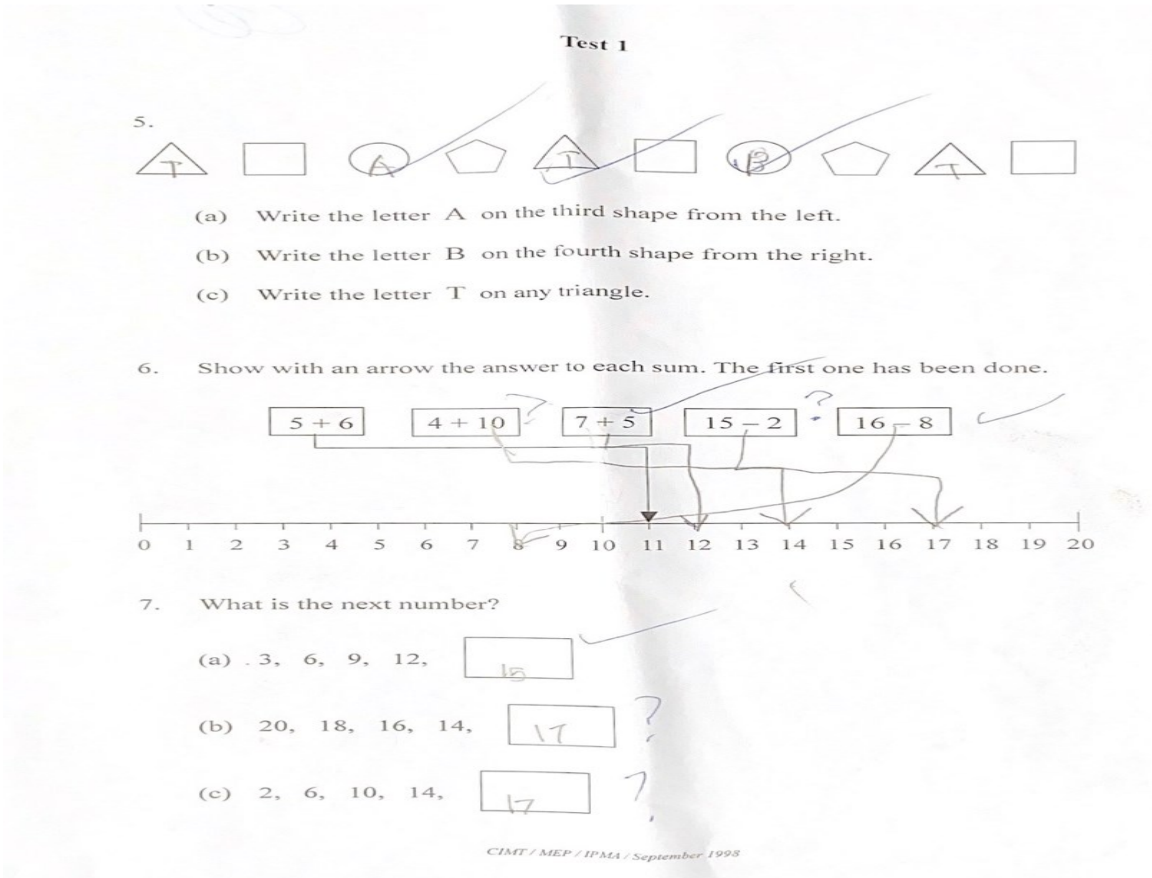
4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

1 4 7 10 12 15 18

(b) Circle all the odd numbers. ?

CIMT / MEP / IPMA / September 1998



Test 1

5.

T A T B T

(a) Write the letter A on the third shape from the left.

(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

6. Show with an arrow the answer to each sum. The first one has been done.

5 + 6 4 + 10 ? 7 + 5 15 − 2 ? 16 − 8

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

7. What is the next number?

(a) 3, 6, 9, 12, 15

(b) 20, 18, 16, 14, 17 ?

(c) 2, 6, 10, 14, 17 ?

CIMT / MEP / IPMA / September 1998

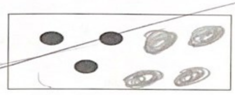
Grade 2 Pre-Test.

4/20

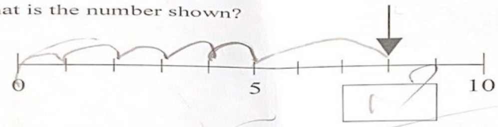
[redacted]

TEST 1

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



3. Fill in the missing numbers.

(a) 2 + 3 = 5 (b) 4 − 1 = 2 ?

(c) 3 + 4 = 7 (d) 4 + 8 = 9 ?

(e) 8 − 2 = 3 ? (f) 10 + 7 = 7 ?

4. (a) Write these numbers in order of increasing size.

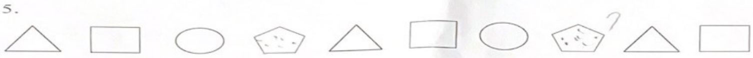
12, 7, 15, 4, 1, 10, 18 1/2

. . . .

(b) Circle all the **odd** numbers.

Test 1

5.

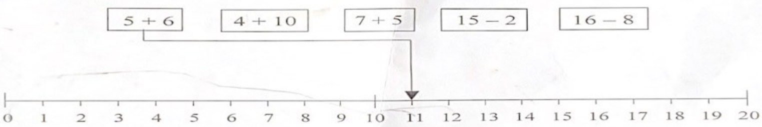


(a) Write the letter A on the third shape from the left.

(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

6. Show with an arrow the answer to each sum. The first one has been done.



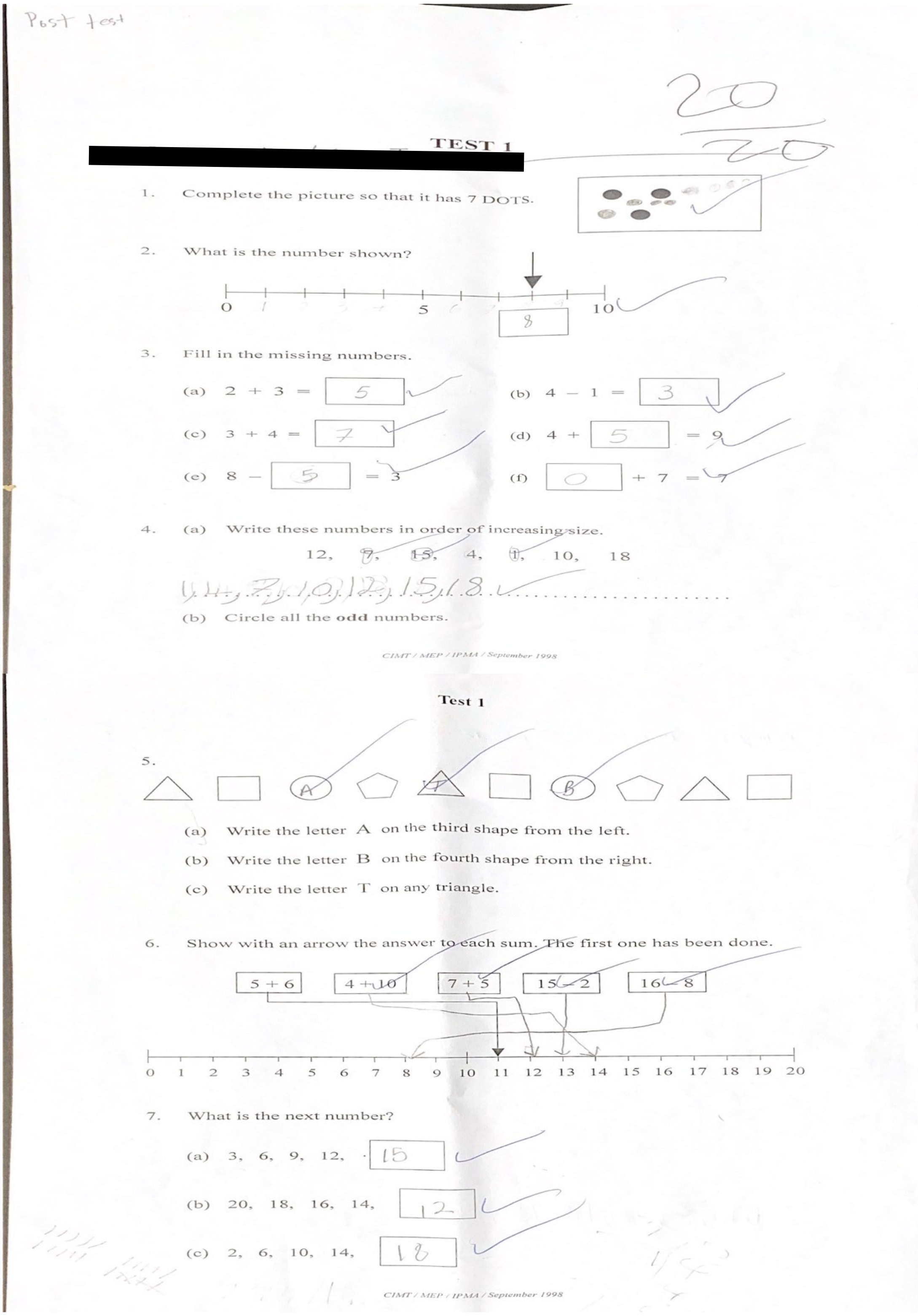
7. What is the next number?

(a) 3, 6, 9, 12, 11 ?

(b) 20, 18, 16, 14, 18 ?

(c) 2, 6, 10, 14, 20 ?

Appendix F – 3: Sample Post-Test Scripts for the Grade One Participants



Post test

20/20

[redacted] TEST 1

1. Complete the picture so that it has 7 DOTS.

2. What is the number shown?

0 1 2 3 4 5 6 7 8 9 10

8

3. Fill in the missing numbers.

(a) 2 + 3 = 5

(b) 4 − 1 = 3

(c) 3 + 4 = 7

(d) 4 + 5 = 9

(e) 8 − 5 = 3

(f) 0 + 7 = 7

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

1, 4, 7, 10, 12, 15, 18 ....

(b) Circle all the **odd** numbers.

CIMT / MEP / IPMA / September 1998

Test 1

5.

A T B

(a) Write the letter A on the third shape from the left.

(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

6. Show with an arrow the answer to each sum. The first one has been done.

5 + 6 | 4 + 10 | 7 + 5 | 15 − 2 | 16 − 8

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

7. What is the next number?

(a) 3, 6, 9, 12, 15

(b) 20, 18, 16, 14, 12

(c) 2, 6, 10, 14, 18

CIMT / MEP / IPMA / September 1998

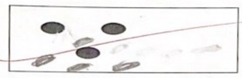
Post test

15/20

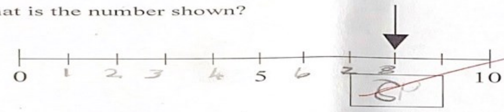
TEST 1

[redacted]

1. Complete the picture so that it has 7 DOTS.



2. What is the number shown?



3. Fill in the missing numbers.

(a) 2 + 3 = 5 (b) 4 − 1 = 3

(c) 3 + 4 = 4 ? (d) 4 + 5 = 9

(e) 8 − 5 = 3 (f) 0 + 7 = 7

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

1 4 7 10 12 15 18

(b) Circle all the **odd** numbers.

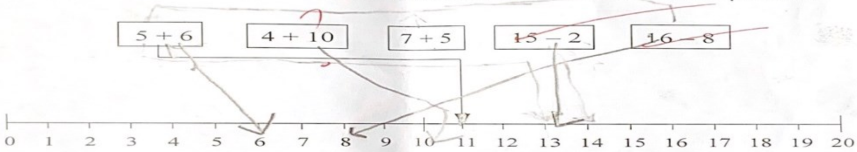
5.

(a) Write the letter A on the third shape from the left.

(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

6. Show with an arrow the answer to each sum. The first one has been done.



7. What is the next number?

(a) 3, 6, 9, 12, 15

(b) 20, 18, 16, 14, 12

(c) 2, 6, 10, 14, 17 ?

Appendix F – 4: Sample Post-Test Scripts for the Grade Two Participants

1st 7 Questions $\frac{20}{20}$

$\frac{38}{40}$

TEST 2

[redacted]

1. Complete the picture so that it has 7 DOTS.

2. What is the number shown?

0 5 10

8

3. Fill in the missing numbers.

(a) 2 + 3 = 5

(b) 4 − 1 = 3

(c) 3 + 4 = 7

(d) 4 + 5 = 9

(e) 8 − 5 = 3

(f) 0 + 7 = 7

4. (a) Write these numbers in order of increasing size.

12, 7, 15, 4, 1, 10, 18

1 4 7 10 12 15 18

(b) Circle all the **odd** numbers.

1 7 15

5. A T B

3/3

(a) Write the letter A on the third shape from the left.

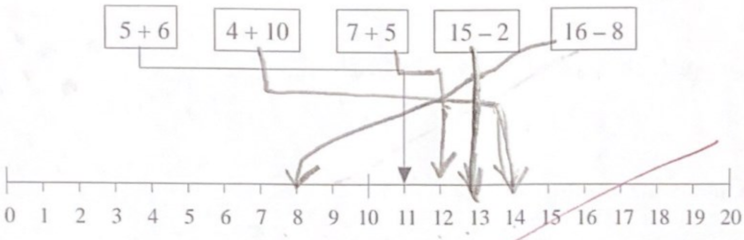
(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

CIMT / MEP / IPMA / September 1998

Test 2

6. Show with an arrow the answer to each sum. The first one has been done.



4

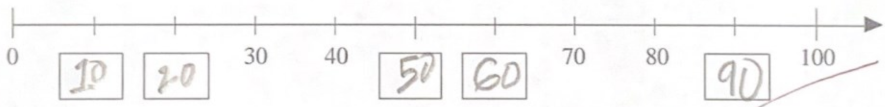
7. What is the next number?

(a) 3, 6, 9, 12, $\boxed{15}$

(b) 20, 18, 16, 14, $\boxed{12}$

(c) 2, 6, 10, 14, $\boxed{18}$

8. Fill in the missing numbers on the number line.



9. Fill in the missing numbers.

(a) 27 + 12 = $\boxed{39}$

(b) 35 – 3 = $\boxed{32}$

(c) 15 + 17 = $\boxed{32}$

(d) 46 – 18 = $\boxed{28}$

(e) 73 + $\boxed{26}$ = 99

(f) 43 – $\boxed{16}$ = 27

Test 2

10. Fill in the missing numbers.

(a) $8 \times 2 = \boxed{16}$ (b) $14 \div 2 = \boxed{7}$

(c) $15 \div \boxed{5} = 3$ (d) $6 \times \boxed{3} = 18$

11. Fill in the missing numbers.

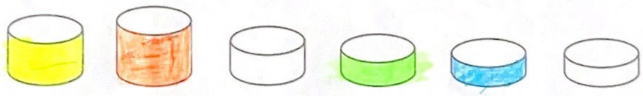
(a) 31, 37, 43, $\boxed{49}$, $\boxed{55}$

(b) $\boxed{5}$, 12, 19, 26, $\boxed{33}$

(c) 3, 9, 27, $\boxed{32}$?

12. Mary buys two sweets costing 20 cents and 23 cents.
What is her change from 50 cents? $\boxed{7}$ cents

13. Colour the weights which together make exactly 17 kg.

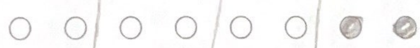


5 kg 7 kg 4 kg 3 kg 2 kg 2 kg

14. Tickets cost \$4 each. How many can be bought for \$15? $\boxed{3}$

15. 20 cards are shared out equally among 5 children.
How many cards does each child have? $\boxed{4}$

16. Colour in a quarter of the total number of circles.



17. Peter thinks of a number. He multiplies it by 3, takes away 2 and gets 25. What was his number? $\boxed{}$?

APPENDIX G: BETWEEN GROUP COMPARISONS OF PRE-TEST SCORES FOR GRADES 1 AND 2 STUDENTS

Variable	Group	Mean	Standard Deviation	Sig. (t-test
Pre-Test (Grade 1)	Intervention	4.63	2.18	.970
	Comparison	4.64	2.21	
Pre-Test (Grade 2)	Intervention	8.89	3.87	.373
	Comparison	8.41	3.60	

APPENDIX H: CHILDREN'S MATHEMATICS ATTITUDINAL SURVEY

Instructions: Read each statement carefully. Please circle your answer which is either no,
unsure or yes.

Grade: _____________ Gender: Male or Female

1. a. I like mathematics 1 - No 2 - Unsure 3 - Yes

   b. Why? (Give a reason for your answer) ____________________________

   ____

2. I can learn mathematics 1 - No 2 - Unsure 3 - Yes

3. a. I like going to mathematics class 1 - No 2 - Unsure 3 - Yes

   b. Why? (Give a reason for your answer) ____________________________

   ____

4. Mathematics is interesting 1 - No 2 - Unsure 3 – Yes

5. My teacher makes mathematics fun 1 - No 2 - Unsure 3 – Yes

6. I enjoy doing mathematics 1 - No 2 - Unsure 3 - Yes

7. I do well in mathematics 1 - No 2 - Unsure 3 - Yes

8. a. Mathematics is hard for me 1 - No 2 - Unsure 3 - Yes

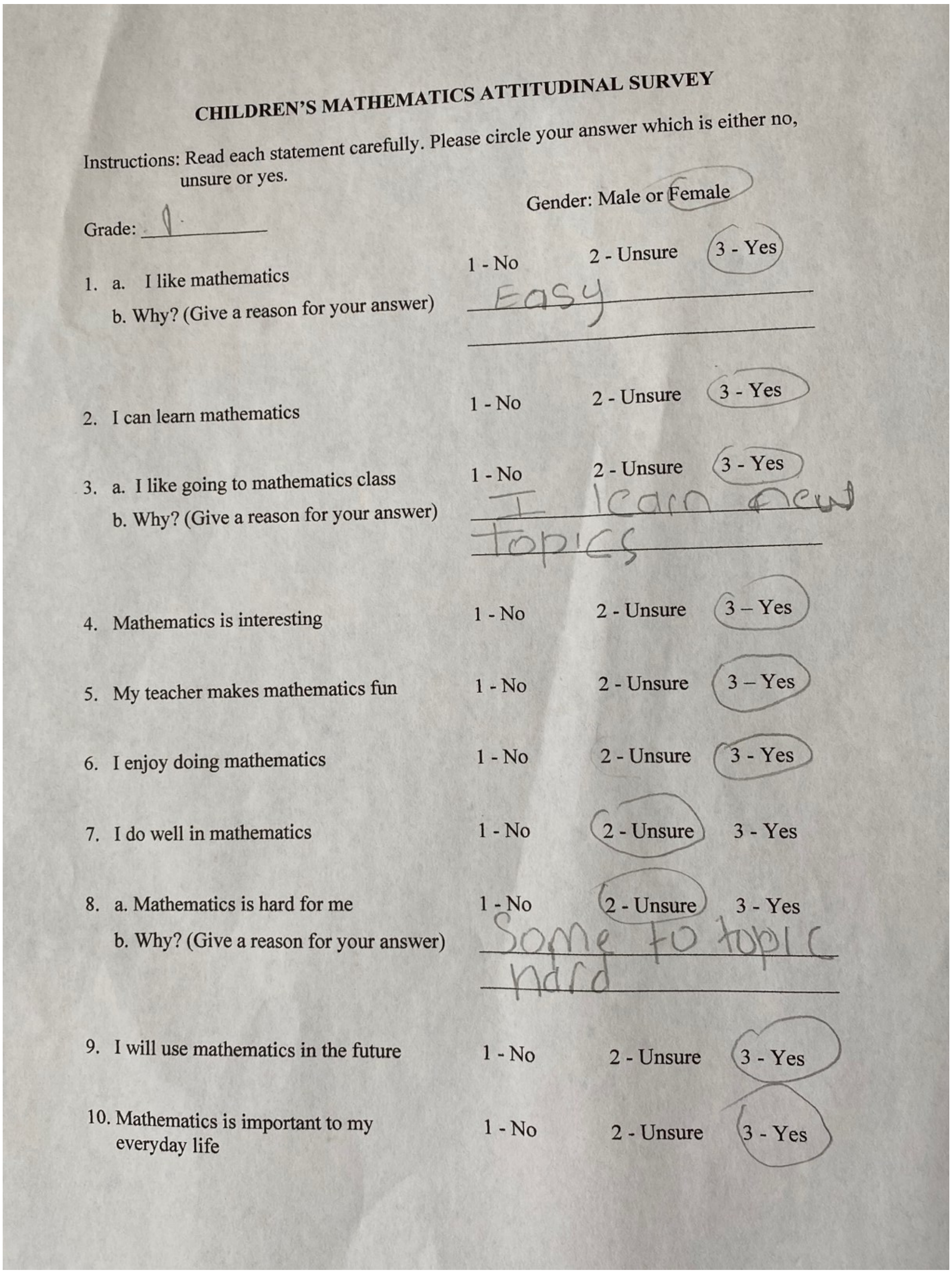
   b. Why? (Give a reason for your answer) ____________________________

   ____

9. I will use mathematics in the future 1 - No 2 - Unsure 3 - Yes

10. Mathematics is important to my everyday life 1 - No 2 - Unsure 3 - Yes

APPENDIX I: SAMPLE RESPONSES TO CHILDREN'S MATHEMATICS ATTITUDINAL SURVEY



CHILDREN'S MATHEMATICS ATTITUDINAL SURVEY

Instructions: Read each statement carefully. Please circle your answer which is either no, unsure or yes.

Grade: 1

Gender: Male or Female

1. a. I like mathematics	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer) Easy			
2. I can learn mathematics	1 - No	2 - Unsure	3 - Yes
3. a. I like going to mathematics class	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer) I learn new topics			
4. Mathematics is interesting	1 - No	2 - Unsure	3 – Yes
5. My teacher makes mathematics fun	1 - No	2 - Unsure	3 – Yes
6. I enjoy doing mathematics	1 - No	2 - Unsure	3 - Yes
7. I do well in mathematics	1 - No	2 - Unsure	3 - Yes
8. a. Mathematics is hard for me	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer) Some to topic hard			
9. I will use mathematics in the future	1 - No	2 - Unsure	3 - Yes
10. Mathematics is important to my everyday life	1 - No	2 - Unsure	3 - Yes

CHILDREN'S MATHEMATICS ATTITUDINAL SURVEY

Instructions: Read each statement carefully. Please circle your answer which is either no, unsure or yes.

Grade: Two 2

Gender: Male or Female

1. a. I like mathematics	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	It is fun		
2. I can learn mathematics	1 - No	2 - Unsure	3 - Yes
3. a. I like going to mathematics class	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	I get to learn new topics		
4. Mathematics is interesting	1 - No	2 - Unsure	3 – Yes
5. My teacher makes mathematics fun	1 - No	2 - Unsure	3 – Yes
6. I enjoy doing mathematics	1 - No	2 - Unsure	3 - Yes
7. I do well in mathematics	1 - No	2 - Unsure	3 - Yes
8. a. Mathematics is hard for me	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	hard when I cannot understand the work		
9. I will use mathematics in the future	1 - No	2 - Unsure	3 - Yes
10. Mathematics is important to my everyday life	1 - No	2 - Unsure	3 - Yes

APPENDIX J: CLASSROOM OBSERVATION GUIDE

Lesson Observation Guide

A. Teachers' profile

Subject……………. Class………….. No. of Pupils……………………….
Gender: …… Age: ……….Teacher's experience: ………….

B. Details of the lesson

Topic:

Does the lesson incorporate the Mathematics Enhancement Programme resources and lessons? Yes/no…

If yes, what aspects of the Mathematics Enhancement Programme were integrated in the lesson?

Mathematics Enhancement Programme Resources and Lessons:

What Mathematics Enhancement Programme resources and lessons were integrated in the lesson?

Teacher's knowledge of the MEP Resources and Lessons:

How informed was the teacher on the Mathematics Enhancement Programme resources and lessons that were inculcated in the teaching and learning experience?

Students' Participation:

How were the students engaged in the lesson by the teacher?

What are the teaching strategies that were employed to integrate the MEP resources and lessons in the teaching and learning episode?

Teaching/learning materials:

What are the teaching/learning materials that were used by the teacher in the delivery of the lesson?

How appropriate were these materials for the lesson that was being taught?

Assignments:

What types of assignments did the teacher give to the students?

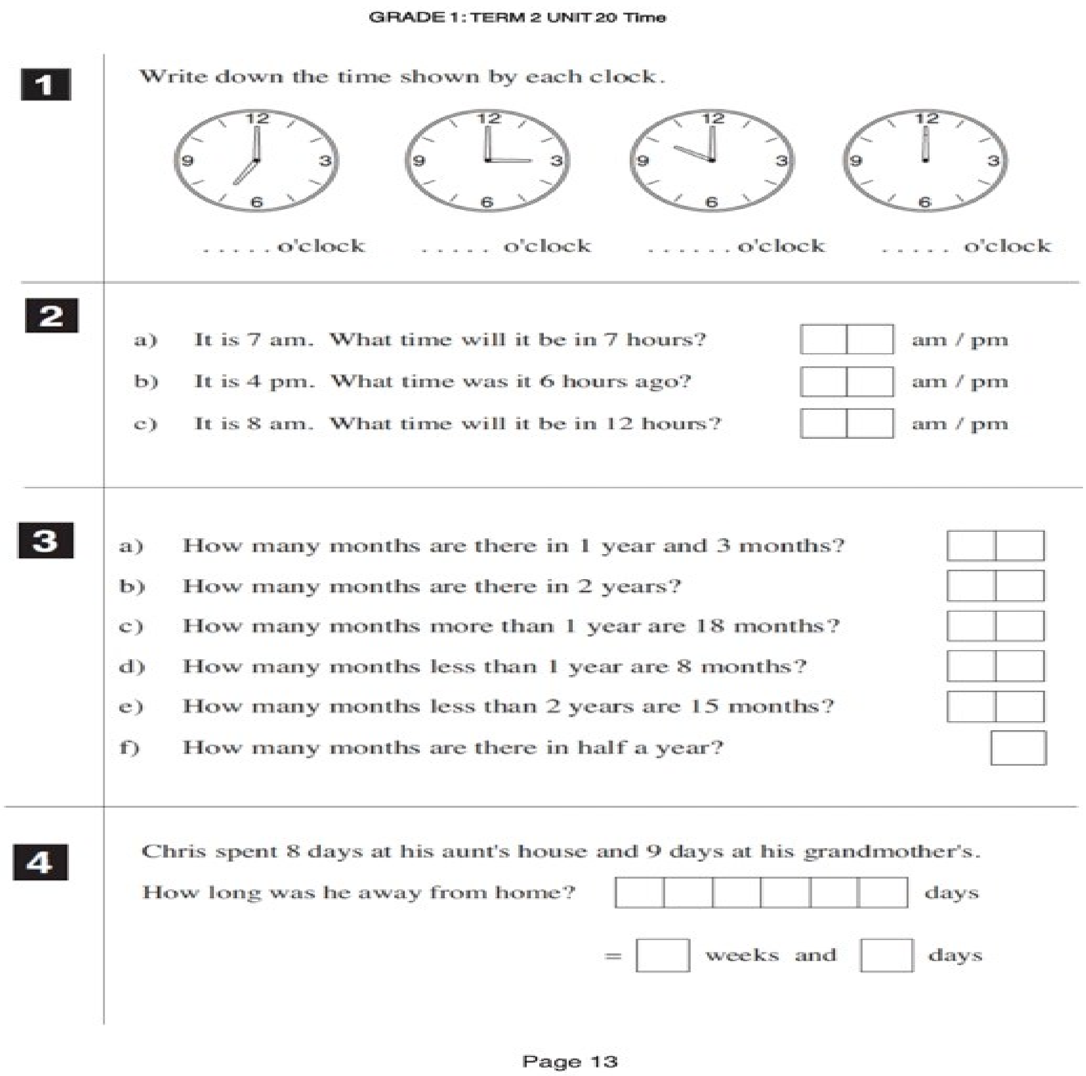
To what extent, were the MEP resources integrated in the activities?

APPENDIX K: EXEMPLAR LESSON OBSERVATION

School B

13/02/2019 9:30am – 10:30am

Year 1 Mathematical reasoning Grade 1 Term 2 Unit 20 Time pg. 13 (See Figure AP1)


GRADE 1: TERM 2 UNIT 20 Time

1 Write down the time shown by each clock.

. . . . . o'clock . . . . . o'clock . . . . . . o'clock . . . . . o'clock

2

a) It is 7 am. What time will it be in 7 hours? ☐☐ am / pm

b) It is 4 pm. What time was it 6 hours ago? ☐☐ am / pm

c) It is 8 am. What time will it be in 12 hours? ☐☐ am / pm

3

a) How many months are there in 1 year and 3 months? ☐☐

b) How many months are there in 2 years? ☐☐

c) How many months more than 1 year are 18 months? ☐☐

d) How many months less than 1 year are 8 months? ☐☐

e) How many months less than 2 years are 15 months? ☐☐

f) How many months are there in half a year? ☐

4 Chris spent 8 days at his aunt's house and 9 days at his grandmother's.

How long was he away from home? ☐☐☐☐☐☐ days

= ☐ weeks and ☐ days

Page 13

Figure AP 1: Time Jamaican MEP Primary. Mathematical Reasoning. Grade 1 term 2 p. 13 (CIMT, 2018)

15 students (out of 16) 9 girls and 6 boys

Teacher discuses and writes the lesson's objectives on the board:

Strand: Measurement

At 9:25 am students were instructed to stand, stretch, or walk around their desks for their two minutes transitional break. Students were very quiet as they stretched and mentally prepare for a new lesson. During this time the teacher placed the students' individual assigned MEP Primary Mathematical reasoning books on the students' desk.

Students were also given their assigned MEP support resources and a small model clock.

At 9:28 The teacher instructed the students to sit and get ready for their math lesson.

Teacher: Today Mrs. Thompson. will be observing our mathematics class. Please stand and make Mrs. Thompson welcome

Students stand and say good morning Mrs. Thompson. Welcome to 1S.
Mrs. Thompson (Researcher): Good morning 1S. Thank you for welcoming me to your class. How are you doing today?

Students: We are fine, thank you and how are you?

Mrs. Thompson: I am doing good. You may be seated.

Students sit.

Teacher: Today, we are going to be learning something new

At 9:31 teacher instructed the students to watch a video entitled ***telling time*** and be prepared to answer the questions that followed
The video entitled ***telling time*** involved the use aminated cartoon-like characters demonstrating in a colourful and friendly environment how to tell time using a 12 hour clock. In the video, the function of each hand on the clock was highlighted. This video lasted for 3 mins and 26seconds.

Teacher: Can someone tell me what we will be learning about today?

Several students raised their hands. Teacher identified a student sitting at the center right of the class (Student C).

Student C: Telling time

Teacher: Do we all agree? Are we going to be learning about time?

Students: Yes miss

Teacher: Good job. We will be learning about using a 12-hour clock to tell time.

Teacher Restate the Objectives for the day:
Objectives: At the end of the lesson, we will
- Tell and show time on a face clock
- Tell time in ‘am’ and ‘pm’
- Use the idea of telling time to solve given problem

Teacher: Can someone share one thing that they have learnt about telling time.

Students raised their hands.

Three students were invited to share their thoughts about telling time

Student A: the shorthand on the clock is the hour hand

Teacher: Good Job!

Student B: the long hand is the minutes hand

Teacher: Very good!

Student X: The clock has a face. Each number on the clock miss is 5 minutes.

Teacher: Super!

Teacher: Thank you students for sharing your ideas about telling time.

Through whole class discussion the concepts surrounding the basic principles associated with telling time were established.

Teacher: 'A clock has two hands. The shorthand on the clock represents the hour hand. It tells you the hour of the day that we are in. The long hand is the minute land; it tells us the minutes. Please also remember that he hands on a clock spin in one direction – clockwise direction.'

With the use of a model face clock the teacher demonstrates how the hands of the clock function in telling time exactly on the hour. The teacher also explained to students that each number on the clock represents five minutes and 60 minutes makes one hour. Students were also able to identify time such as half pass a hour.

Three Student volunteers were then invited to model times 1 o' clock, 5'oclock and 12 o'clock on a 12-hour model face clock.
A student then volunteered himself to show students other time such as 2:30, 4:15

The teacher applauded the students each time they participated.

At 9:52 am, the students were directed to turn to page 13 of their MEP mathematical reasoning book (teacher projected the page of the book on the screen). Once all the students were on that page, the teacher explained the instructions for activity 1 on page 13 (Write down the time shown by each clock). Students were then instructed that they had 5minutes to try those questions based on the previous activities that were done. The teacher walked around the class and carefully monitored what the students were doing and answered any questions that were asked by individual students.

Teacher: Very good job. I have seen where most of you were able to write down the time seen on the face of each clock. Excellent!
Teacher then invited students to share their solutions to the assigned exercise. A whole class interactive discussion followed where students were allowed to agree/disagree with the answers provided and any student who disagreed was allowed to share his/her alternate response. The teacher then took a few minutes to go over some key points before she continued with her lesson.

Teacher: Do you know the difference between 'am' and 'pm' when reading time

Students raised their hands and said 'me miss, me miss….'
Teacher reminded students of the need to wait until they are identified before they begin to speak. A student from the back right (Student Z) was identified:
Student Z: Miss 'am' is from midnight until just before we get lunch break at 12noon.

But 'pm start at 12noon until 11:59pm. Right miss.

Teacher: Very good job with your explanations.

Any other student wants to share their thoughts:

Student A: Miss, 'am' is from before day - 12am until 11:59am just before we eat

lunch. 'pm' is lunch time 12pm until 11:59pm.

Teacher: Super. Good job explaining.

Teacher: So, as you already know, we have 24 hours in a day. The 12-hour clock divides the day into two periods 'am' and 'pm'. Boys and girls each period have 12 hours.
Teaching pointing on her model clock demonstrates the 12 hours in each period: 12, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11. The teacher then built on the students explanations that addresses the 'am' hours and the 'pm' hours.

The teacher then projected activity two on the board and asked the students to read question a 'It is 7am. What time will it be in 7 hours?'

Teacher: Please do not rush and give me any answers, I need you to all set your clock to 7'oclock. Teacher monitors the process.

Now, let us assume that this is showing 7am. Please also remember that each 12 hour period runs from 12, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11. If this is our 'am' period it means that after this 11, the 12 that would follow could take us to the 'pm' period.
Any questions?

Student L: 'suh miss afta the 'am' period done, di next 12' o clock a guh start the 'pm' period? Same like how wi lunch time start di 'pm'?'

Teacher: Very Good. Yes.

Teacher: Any other questions?

Students: No miss

Teacher: Ok, we have already identified 7am on our model clocks. Let us now add seven hours by adjusting the hands on our clocks seven times.

Teacher gives students time to complete the task

Teacher: Based on the little activity that you just completed what would be the answer to question a 'It is 7am. What time will it be in 7 hours?'

Students raised hands and waited to be identified

Student A: 2 pm

Student F: 2

Teacher: Is it 2 am or 2 pm?

Student F: pm teacher

Student C: 2pm miss

Teacher: Is there and other student with a different answer.

Student B: No miss, I see how we got the 2 but tell me how we get the 'pm' again.

Student A raised hands and asked the teacher if she could explain.

Teacher gives Student A permission

Student A: 'You see like how when wi come a school wi in the 'am' and at lunch time wi start pm. Is the same thing, once wi have 'am' time from 12 to 11, when the other 12 hours start wi now in the pm; after the pm finish wi guh back to the am. Just memba 12midnight until 11:59 in the morning a am and from 12 lunch time till night at 11:59 a 'pm'….once the clock reach 12 a waan new period right miss?'

Student B: Oh, I see. Thank you.

Teacher: Thank you student A.

The teacher then further explains how each day has 24 hours and how the clock divides the day into two 12-hour periods. She also explicitly pointed out to students what each

12-hour period looks like and the time on the clock that changes the period from ‘am’ to ‘pm’

Teacher: Are there any other questions?

Students: No Miss

Teacher: Do you understand?

Students: Yes Miss

At 10:23am

Teacher: Please complete questions ‘b’ and ‘c’ in your workbook’ Teacher monitored the students’ progress

At 10:30am, the teacher invited students to share their responses to the questions ‘a’ and ‘b’. She then did a recap of the lesson and session ended at approximately 10:36am

APPENDIX L: EXEMPLAR LESSON USING LESSON OBSERVATION GUIDE

Teachers' Profile

Subject Mathematics	Class 1S	No. of Pupils 15
Gender Female	Age Range 25-35	Teachers' Experience 3 years

B. Details of the lesson

B. Details of the lesson
Topic: Telling Time using the 12 hour clock
Does the lesson incorporate the Mathematics Enhancement Programme resources and lessons? Yes/no…

If yes, what aspects of the Mathematics Enhancement Programme were adapted, tailored and integrated in the lesson?

The teacher incorporated the lesson on time from unit 20 of the MEP Primary Mathematical Reasoning workbook in her lesson.

Mathematics Enhancement Programme Resources and Lessons:
What Mathematics Enhancement Programme resources and lessons were integrated in the lesson?

Selected Activities from the MEP Primary Mathematical reasoning workbook were integrated in the lesson

Teacher's knowledge of the MEP Resources and Lessons:
How informed was the teacher on the Mathematics Enhancement Programme resources and lessons that were inculcated in the teaching and learning experience?

The teacher was knowledgeable about the expectations of the selected MEP lesson. The lesson was planned and organized. Her pacing was however slower than the MEP recommended pace. This may be because of her using other aids to arouse students' interest in the lesson and using model clocks to aid in building students' understanding of telling time before allowing them to attempt the activities in the workbook. The teacher was however keen on checking for students understanding and acted as a model for the learners to follow

Students' Participation:
How were the students engaged in the lesson by the teacher?
What are the teaching strategies that were employed to integrate the MEP resources and lessons in the teaching and learning episode?

The students were actively involved in participating in whole class discussions and activities. Students were also engaged at a point in the lesson to discover through the use of model clocks how to answer questions that involved ‘am’ and ‘pm’. The students were also given questions from the MEP primary Mathematical reasoning book page 13 activities 1 and 2 to complete

The teaching strategies that were employed are:

- Use of technology
- Focus whole group discussions
- Use of models
- Questioning
- Mini discovery learning

Teaching/learning materials:
What are the teaching/learning materials that were used by the teacher in the delivery of the lesson?

- MEP primary Mathematical Reasoning workbooks
- 12-hour face clock models
- Computer
- Projector
- Speakers
- Whiteboard
- Markers

How appropriate were these materials for the lesson that was being taught?

The materials used were instrumental in engaging the students throughout the lesson.

Assignments:
What types of assignments did the teacher give to the students?
To what extent, were the MEP resources integrated in the activities?

The teacher assigned activities 1 and 2 from Unit 20: Time of the MEP Primary Mathematical Reasoning workbook Grade 1 Term 2 page 13 for students to complete.

Strategies employed:

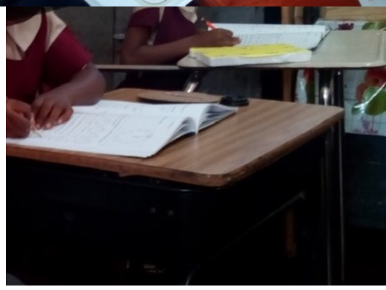
- Use of technology
- Use of manipulatives in the form of model clocks
- Questioning
- Discovery learning

APPENDIX M: IMAGES FROM FIELD WORK

Appendix M – 1: Image from the SKE Certification Ceremony

Appendix M – 2: Images from the Distribution Recourses Sessions

Appendix M – 3: Images from Classroom Observations



APPENDIX N: GUIDING INTERVIEW QUESTIONS - PARTICIPATING TEACHERS

This interview is solely being conducted as a requirement for the partial fulfilment of the research project associated with the MPhil/PhD Programme that I am enrolled in. All information given will be held strictly confidential and will only be used for the purpose of this research.

1. What are your experiences like being a teacher of mathematics at this institution?
2. What do you understand by the phrase 'Mathematics Enhancement Programme'?
3. In your teaching practices, have you ever incorporated any mathematics enhancement programme in your mathematics lessons?
4. How do you incorporate the Mathematics Enhancement Programme resources in your mathematics lessons?
5. a. What are some of the teaching strategies that you use to incorporate the Mathematics Enhancement Programme resources in your mathematics classes? Why do you employ these teaching strategies and how effective are these teaching strategies?
   b. Which of these teaching strategies do you deemed as been most effective in integrating the MEP and why?
6. What do you consider to be barriers to incorporating the Mathematics Enhancement Programme resources and teaching strategies in Jamaican Primary Classrooms?
7. How do you think the incorporating of Mathematics Enhancement Programme resources can be improved in Jamaican Mathematics Classrooms?

8. To what extent do you think you have been successful in incorporating the Mathematics Enhancement Programme resources in your mathematics classes?
9. Are there any benefits to be gained from adapting aspects of the Mathematics Enhancement Programme and incorporating it in the Jamaican Mathematics Curriculum? Give reasons for your answer.
10. What aspects of the MEP would you adapt and implement in your own practice as a classroom teacher?

APPENDIX O: SAMPLE INTERVIEW WITH TEACHER JY

Researcher: Good morning. Thank you for agreeing to this interview. This interview is solely being conducted as a requirement for the partial fulfilment of the research project associated with the MPhil/PhD Programme that I am enrolled in at University of Plymouth. All information given will be held strictly confidential and will only be used for the purpose of this research.

Teacher JY: Good morning and you are welcome.

Researcher: How long have you been working at this institution?

Teacher JY: Over 10 years

Researcher: What are your experiences like being a teacher of mathematics at this institution?

Teacher JY: It has been a good and rewarding experience although there are several challenges that I have faced throughout my tenure. Some of the challenges include the limited resources that I have working with, students lack motivation to learn the subject and lack of parental support. The rewarding experience for me is when I can help students meet or exceed growth.

Researcher: What do you understand by the phrase 'Mathematics Enhancement Programme'?

Teacher JY: A programme design to enrich the teaching and learning of Mathematics

Researcher: In your teaching practices, have you ever incorporated any mathematics enhancement programme in your mathematics lesson?

Teacher JY: This MEP that you have introduced to us is the first Mathematics Enhancement Programme that I have incorporated my lessons.

Researcher: How do you incorporate the MEP resources in your mathematics classes?

Teacher JY: First I check our ministry of Education pacing guide and find the corresponding MEP lesson that is geared at meeting the same objective. I then look at the MEP teacher's guide and familiarize myself with the structure and flow of the lesson. On the day of the lesson, I ensure that all students have their MEP workbooks and supporting materials. When I teach the concepts, I use the teachers' guide. I ensure that there is whole class interaction, and that the language of mathematics is enforce.

Researcher: What are some of the teaching strategies that you use to incorporate the MEP resources and lessons in your mathematics class?

Teacher JY: Technological aids such as computers and projectors
Songs, visual aid, discussions

Researcher: Why do you employ these strategies and how effect are these teaching strategies?

Teacher JY:

- o I use technological aids such as computers and projectors. I find this to be a good way to give whole class instructions when using the MEP resources. It is also a good way for me to model the tasks that students have to do for them to follow
- o Sometimes I create songs to help students remember the concepts covered
- o I also use discussions especially 'think-pair-share'. I find that think-pair-share discussions were very useful in my MEP lessons. Students shared freely with their pair partner. They seem very comfortable talking to their friends. This I think boasted students' confidence to participate in the whole group discussion which usually follow. Also, I find that students participate more when I use this approach to teach my MEP lessons.

These strategies help to engage the students, enhance their participation and I t think it helps with their retention of what was taught in class.

Researcher: Which of these do you deem as been most effective in integrating the MEP and Why?

Teacher JY: For me the use of Technology and discussions have been most effective in integrating the MEP in my math class. I find that technology has been useful in helping my students get a visual idea of the mathematics concepts that were being explained and it boosted their understanding of the MEP math content that was being taught. Also, the use of technology helps to create good visuals when I explain the given tasks to students. It is also good for whole class explanation as it big and clear enough for all students to see all at once. Discussions have also been every effective in integrating the MEP. I find Think pair square discussions to be effective. Think-pair-square was a very powerful method that aided with the integration of the MEP. Some of my students were initially shy to speak in the whole class discussions but were very open to discuss their work with their elbow partners. Overtime this boosted their confidence and I found that it subsequently positively impacted how students participated in whole class discussions.

Researcher: What do you consider to be barriers to incorporating the MEP resources and teaching strategies in Jamaican Primary Classrooms?

Teacher JY: I foresee two barriers to integrating the MEP. It takes a lot of time to learn the method and to ensure that it fits into our curriculum and if teachers are not very strong in mathematics. The MEP: it is time consuming. As a teacher I have to dedicate quality time to ensure that I understand the material well before I teach my class. The MEP is a very good programme but I see teachers who are not trained in mathematics struggling to effectively integrate the MEP in their mathematics classrooms. Teachers must be good at mathematics to be effective in explaining some of the MEP activities to students. For the MEP to be rolled out as a national initiative, teacher would need to be trained in mathematics and their content knowledge will need to be optimal.

Researcher: How do you think that the incorporating of the MEP resources and lessons can be improved in Jamaican Mathematics classrooms?

Teacher JY: by using or applying continuous rigorous lesson study and training sessions

Researcher: To what extent do you think you have been successful in incorporating the MEP

Teacher JY: I think that I was effective in incorporating the MEP in my classroom. I have seen where students grew to love and appreciate the activities and overtime my lessons transitioned smoothly

Researcher: Are there any benefits to gain from adapting aspects of the MEP and incorporating it in the Jamaican Mathematics curriculum? Please give reasons for your answer.

Teacher JY: Yes – the programme will help us as teachers to guide our students into developing their critical thinking and analytical thinking skills. The work provided in the workbooks require of students to think critically so we are forced to teach them how to be effective problem solvers. This has really helped our students to become better at solving math problems.

Researcher: What aspect of the MEP would you adapt and implement in your own practice as a classroom teacher?

Teacher JY: I like the recommended MEP seating. I think that when students can easily access the board, it will be less time consuming when students volunteer or are being asked to share his/her response to a problem. I will try to infuse this into my practice as much as possible. I also live that the programme enforces the use of manipulatives and visual aids. I believe that manipulatives and visual aids have been useful in helping to develop students understanding of various MEP math concepts. Also, they were also useful in demonstrating various MEP math concepts that were developed in my classes.

Researcher. Thank you for sharing your experience integrating the MEP into your classroom. I really appreciate it. Have a great day.

Teacher JY: You are welcome

APPENDIX P: GUIDING FOCUS GROUP INTERVIEW QUESTIONS (STUDENTS)

This interview is solely being conducted as a requirement for the partial fulfilment of the research project associated with the MPhil/PhD Programme that I am enrolled in. All information given will be held strictly confidential and will only be used for the purpose of this research.

1. What is your favourite subject?
2. Do you like mathematics? Give a reason for your answer.
3. Do you like attending mathematics classes? Give reasons for your answer.
4. What do you like most about your mathematics class?
5. What are some of the things that your teacher uses when teaching mathematics?
6. Does the use of these things help you to understand mathematics more? Please give reasons for your answers.

APPENDIX Q: CODING SAMPLE FROM THE FOCUS GROUP INTERVIEW

Participating school 1: June 17, 2019

Researcher: Good afternoon

Students: Good afternoon miss

Researcher: How are you doing this afternoon?

Students: We are doing fine, thank you and how are you?

Researcher: I am doing ok. Thank you. My name is Shandelene Binns-Thompson, and I am a student also. I attend the University of Plymouth in England.

Students: wow

Researcher: Yes! when you are big you will also get the opportunity to attend a university. You are meeting with me this afternoon to talk about your math classes. I want to know more about your mathematics classes and how you feel about them. This interview is being done as a requirement for a research project that I am doing at the University of Plymouth. All the information that you give me will only be used for this project.

Students: Ok miss

Question 1:
Researcher: Before we begin to talk about mathematics, can you tell me what is your favourite subject?

Students:
A – Math
b- Language Arts

C- Integrated Study

D- Math

E- Math

F- Integrated study

Question 2:
Researcher: Do you like Mathematics? Give a reason for your answer

Students:

a Yes- it is my favourite subject
b Yes- My teacher makes it fun. I like maths now
c Yes - My teacher makes it easy to understand so I like it now
d Sometimes – Sometimes it is easy and fun, sometimes it is hard
e Yes- It is fun to do and I can do the work miss gives
f Yes – It is fun and I use it when I go to the shop to buy things.

Question 3:
Researcher: Do you like attending mathematics classes? Give a reason for your answer.

Yes-

A – Teacher is fun

B - I am learning in class

C- class is nice

D – We get to learn new maths

E – miss makes math fun

Sometimes

G – sometimes the work is hard and I get nervous but my teacher is fun

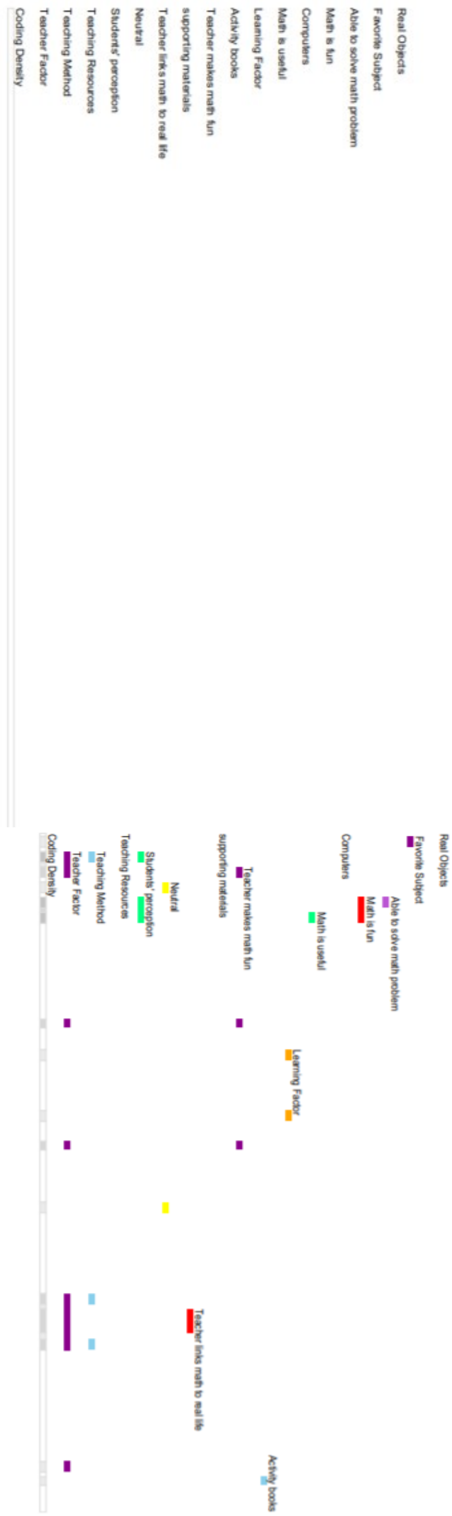
Researcher: Thank you. You said that your teacher is fun, what are some of the fun things that she does during maths class?

A Miss sometimes makes math songs. This helps me to remember more of the math.
B She makes the math real when she carries stuff to class and use them to help us understand the math
C She shows us video of other students using the same activity books that we use.

Question 4:
Researcher:
What do you like most about your math class?

Students:

a My teacher
b The books that we use



c Miss gives us things like number line, number cards and shape cards. These help me to do the work miss gives me.
d The things we do while in math class. We sing and role play
e The math songs we sing
f The activity books we use

Question 5:
Researcher:
What are some of the things that your teacher uses when teaching mathematics?

Students:
a Computer
b Activity books, number lines
c Shape cards
d Number cards
e Things in our class
f The workbooks and computer

Question 6:
Researcher: Does the use of these things help you to understand mathematics more? Please give a reason for your answer.

Students:
A Yes- I understand more when I see the work on the computer
B Yes - the number lines help me to count and add
C Yes -The number cards and shape cards help me to answer the questions my teacher gives us
D The activity books are fun to use to I understand when Miss use them
E Yes - They just help me understand more
F Sometimes - they make the lesson easier to understand

Researcher: Thank you for your time and for talking to me about your math classes. I will only be using this information for the purpose of my research.

Students: You are welcome miss.

APPENDIX R – REFLECTION/LESSON/CONTINUED PROFESSIONAL DEVELOPMENT SESSION GUIDE

Warm up Activities
Glows and Grows
Reflections
Lesson study
Lesson study reflection guide

- To what extent did the lesson incorporate the MEP resources?
- To what extent did the lesson meet the learning objectives?
- Did the lesson build on previously learnt concepts?
- What teaching strategies were employed during the lesson?
- How did the teaching strategies employed during aid in enhancing students' learning?
- How did the lesson facilitate enrichment and remediation?
- What supporting resources and visual aids were used during the lesson?
- How did the use of these resources impact the teaching and learning of mathematics?

Extend and enhancement activities
Adjournment

APPENDIX S – PUBLICATIONS

education sciences

MDPI

Article

Investigating the Impact of a Mathematics Enhancement Programme on Jamaican Students' Attainment

Shandelene Khadine Kedisha Binns-Thompson *, Garry Hornby * and David Burghes *

Institute of Education, University of Plymouth, Drake Circus, Plymouth PL4 8AA, Devon, UK
* Correspondence: shandelene@gmail.com (S.K.K.B.-T.); garry.hornby@plymouth.ac.uk (G.H.); david.burghes@plymouth.ac.uk (D.B.)

Abstract: Underperformance in mathematics has been an issue that plagues the education system in Jamaica. Studies in first world countries have shown that enrichment programs, including Mathematics Enhancement Programmes (MEPs,) have been positively impacting attainment in mathematics. This quasi-experimental research design study investigated the impact of an MEP on Jamaican students' attainment in mathematics. A sample of seven grade one classes from two primary schools in representative areas in Jamaica were selected for the intervention group. The treatment involved teaching the Jamaican grade one mathematics standards using the MEP resources for nine months. A statistically significant improvement and large effect size of the intervention was found, indicating that the MEP had a substantial impact on students' achievement and attitudes towards mathematics. This study has implications for designing enrichment programs geared at addressing mathematics underperformance in Jamaica and in similar countries.

Keywords: Mathematics Enhancement Programme (MEP); attainment; attitude

check for updates

Citation: Binns-Thompson, S.K.K.; Hornby, G.; Burghes, D. Investigating the Impact of a Mathematics Enhancement Programme on Jamaican Students' Attainment. *Educ. Sci.* **2021**, *11*, 516. https://doi.org/10.3390/educsci11090516

Academic Editor: Miklos Hoffmann

Received: 30 July 2021
Accepted: 25 August 2021
Published: 7 September 2021

1. Introduction

1.1. Overview of Jamaica and Its Education System

Jamaica is nested in the Greater Antilles, is the largest island in the Caribbean Sea and boasts a very rich and varied landscape [1]. The island is globally recognized through its reggae music and its participation in international sporting events [2,3]. The population of Jamaica emerged from a historical process that brought people from different continents together. Jamaica's culture is heavily influenced by its African heritage, while formal behaviour is unmistakably British in style [1].

Jamaica's education system is best explained and understood in the context of the island's colonial history [4]. Prior to the slaves being emancipated in 1834, Jamaica had a minimal formal and cohesive education system for whites and no system for educating its indigenous people and slaves [4,5]. Only a few slave children were privy to schooling which focused on religion and virtues of submission at plantation schools established by foreign missionaries. Once slavery was abolished in 1834, education was viewed as an important way to integrate ex-slaves into the colonial economy and to ensure a peaceful lower class. After gaining independence in 1962 all children were allowed to attend infant and elementary schools [6] but only a few students had access to secondary education due to the need to pass a stringent primary exit examination and financial constraints for those who passed the exam [6]. In the years following independence, leading up to the late 1970s educational provisions in Jamaica were still limited, resulting in the nation having a high level of illiteracy. During the 1980s, educational provisions deteriorated and 'the poorer strata in the society were generally more seriously affected by the deteriorating provision' [7]. During this period, teachers had limited or no resources to work with, enrolment in primary schools declined and there were high levels of grade repetitions and school dropouts. Currently, Jamaica is transforming its education system and building the capacity of a network of institutions to improve the quality of its educational services [8].

1.2. Background to the Study

It is Jamaica's vision to develop an education and training system that produces well rounded and qualified individuals who will be empowered to learn for life and productively function in society and be competitive in a global context [9]. As Jamaica strives to take its place within a fiercely competitive and highly globalized marketplace, its school graduates must be equipped with the requisite mathematical knowledge needed to access the kinds of jobs that are emerging and to be able to compete internationally [10]. This vision is, however, hampered by the underachievement that still prevails in mathematics in Jamaica despite efforts to improve mathematical instructions. This view has been endorsed by Buddo [11], who opines that the school subject of mathematics in Jamaica has always presented challenges for learners at all levels of the educational system. Buddo [11] further lamented that, since the 1980s, the Jamaican Ministry of Education has embarked on various projects or initiatives to address the poor performance in mathematics by students who sit the national assessment tests or the Caribbean Examination Council's Secondary Education Certificate Examination (CSEC). However, despite these interventions, the overall performance in mathematics continues to be below expectations. It is clearly evident from statistical data, which show that, for the ten-year period 2009–2018, students' average attainment rate on: The Grade Four Numeracy Test fluctuated between a low of 41 percent and a high of 66 percent; The Grade Six Achievement Test (GSAT) scores in mathematics fluctuated between a low of 53 percent and a high of 62 percent; The Caribbean Secondary Examination Certificate (CSEC) examination fluctuated between a low of 31.7% and a high of 62% [12].

The unsatisfactory performance of students in mathematics and the low levels of numeracy exhibited by students and graduates of the Jamaican educational system have been a cause of much concern for stakeholders in education in the private and public sectors [10]. As stated in Jamaica's mathematics and numeracy policy, the Ministry of Education, Youth and Culture (MOEYC) recognised that the nature of teaching and learning is a contributing factor to the poor performance and underachievement in mathematics [10]. Ministry policy has identified effective teacher pedagogy as an important tool that can be used to promote high levels of numeracy and facilitate the overall mathematical development and achievement of students. It was clearly outlined in the policy that experiences provided in the classroom should be geared towards the development of skills which enable not only meaningful use of the ideas learnt but also the development of problem solving and critical thinking skills. This is difficult to achieve, however, unless focus is placed on the quality of mathematics teaching. As suggested by the Ministry of Education [10], mathematics lessons should be focused on facilitating the development of problem-solving skills so that mathematics teaching at all levels of the educational system will enable the development of analytical, reasoning and critical thinking skills. One way to achieve this goal is to identify, adapt and implement the best practice observed in mathematically high-performing countries.

The Mathematics Enhancement Programme (MEP), which was pioneered by Professor David Burghes, is based on the premise of best practices observed in mathematically high-performing countries such as Hungary, Poland, Czech Republic, Japan, Singapore and Finland [13,14]. Therefore, the structure of the MEP may be able to help the Jamaican education system address some of the issues it faces in its mathematics classrooms. As suggested by Burghes [14], the MEP is geared at helping students develop their analytical and critical thinking skills, which are the skills that the Jamaican educational system identifies as being critical if performance in mathematics is to be improved [10]. Studies have shown that the MEP has been able to positively impact performance in mathematics in several first world countries [13,14]. The question then is that if the MEP is adapted, tailored and implemented in Jamaican mathematics Primary classrooms, would it have a similar impact. This study investigated the impact of the MEP has on Jamaican students' attainment in mathematics.

Studies have shown that there is a significant correlation between students' attitude towards mathematics and their performance in the discipline [14–17]. As defined by Eshun [18], attitude towards mathematics is 'A disposition towards an aspect of mathematics that has been acquired by an individual through his or her beliefs and experiences, but which could be changed'. Zan and Martino [19] suggested that a positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject and a negative attitude towards mathematics relates to a negative emotional disposition. Eshun [18] added that a student's disposition towards a subject area affects the way he/she performs in the subject. It was also suggested by Eshun [18] that one is likely to achieve better in a subject that one enjoys, has confidence in or finds useful. Evidence of this was recorded in the work of Nicolaidou and Philippou [16] where is it was found that students who had a positive attitude towards mathematics performed better than those who displayed a negative attitude. Eshun [18] concluded that positive attitudes towards mathematics are desirable since they may influence one's willingness to learn and the benefits one can derive from mathematics instruction. For a Mathematics Enhancement Programme to be effective, it must aid in helping students develop a positive attitude towards the subject. What impact will the MEP have on students' attitude towards mathematics? To answer this question, this study also investigated the impact the MEP has on students' attitudes towards mathematics.

1.3. Research Questions

This research was guided by the following questions:

1. What effect does the implementation of MEP have on Jamaican primary school students' performance in mathematics?
2. How does students' participation in the MEP impact their attitude towards mathematics?

2. Perspectives

2.1. The Impact of Enrichment Programmes on Mathematics Education

Studies have shown that the implementation of enrichment programs aid in nurturing social and behavioural skills, as well as academic skills [20,21]. Enrichment in mathematics helps to deepen students' mathematical understanding [22]. Additionally, it has been found that the implementation of enrichment programs in mathematics positively impact performance in the discipline [23,24].

Enriched mathematics classrooms have aided in filling the instructional and learning gaps and have been impacting academic achievement [23–25]. The Mathematics Enhancement Programme (MEP) is an enriched mathematics program that is used in primary mathematics classrooms in England [14,26]. The MEP as an enriched Mathematical program has, '... proven to be a successful strategy because of pupils' high attainment in the discipline with a very low standard deviation' [13].

2.2. The Mathematics Enrichment Programme (MEP)

2.2.1. An overview of the MEP

The MEP was based on the observation of best practices in mathematically high-performing countries, such as Hungary, Poland, Czech Republic, Japan, Singapore, Russia and Finland (Burghes 2000; Burghes 2012). In these countries, great emphasis is placed on creating a strong mathematical foundation in the primary years [13,14] on the basis that students from countries which provide a strong mathematical foundation in the primary sector are more capable of being successful at the secondary level [14]. As set forward by McAleavy [26], countries that are strongest in the field of mathematics implement strong mathematical foundations in the primary years and they encourage and enable their pupils to think mathematically and be creative and confident using mathematics. The MEP is focused on enhancing primary mathematics based on the hypothesis that the best way to produce young people who are mathematically confident and capable is to start in the primary phase [14].

'The MEP involves a friendly and non-confrontational style of learning that encourages classes to engage in pupil-led discussions and to find solutions to maths problems; In this context, the teacher orchestrates the activities but does not lead the class in the traditional way [26]'. The MEP is aimed at challenging all abilities with the expectations that attainment will be positively impacted [14]. The MEP provides ample opportunity for educators to develop good classroom practices [14]. As proposed by Burghes 2012, for the MEP to be effectively implemented, some key components need to be implemented, and these are outlined in Table 1.

Table 1. The key components of the Mathematics Enhancement Programme (MEP).

Key Points
• Lesson—well prepared (teacher knows the lesson plan well and is aware of any problems/difficulties which might occur), resources are at hand, board prepared in advance, pupils have own resources on desk.
• Seating—every pupil has direct eye contact with the teacher and can get to the board quickly and easily. Able children seated beside less able.
• Whole-class interactive teaching predominates, with planned intervals of individual and paired work. All pupils on task and all given the chance to demonstrate, answer, explain, suggest, criticise, etc.
• Friendly, non-confrontational atmosphere where pupils learn from and support others and have fun! Mistakes used as teaching points. Encouragement given to pupils who have difficulty and praise given when deserved. Pupils are encouraged to appreciate the good work of others.
• Spiral curriculum with continual revision; learning by heart encouraged with progression in small, logical steps.
• Visualisation and manipulatives are used in the early years and with less able pupils. Contexts are related to pupils' experiences where possible. Demonstrating on a number line and modelling are used to help understanding.
• Exercises reviewed interactively with the whole class at the same time. Pupils give the solutions, not the teacher, and rest of the class agrees/disagrees or suggests alternative solutions. Pupils are expected to correct their own work (i.e., cross out wrong answer and write correct answers in red). Teacher gives hints only if the whole class is stuck.
• Challenges or extension work set for able pupils, or they help their less able neighbours; no one is inactive.
• Correct notation, layout and language used at all times. Teacher acts as a model for pupils to follow (on board and orally), repeating/showing a pupil's explanation more clearly and succinctly where necessary. New words always explained and written on the board for pupils to copy in exercise books.
• Fast paced and varied activities related to the concept being taught. Time limits set for individual/paired work. Time allowed for pupils to explain and for whole-class discussion.

Adapted from [14].

The innovative structure of the MEP ensures that pre-prepared lesson plans and resources support varied, fast paced class work [26]. As stated by McAleavy [26], the spiral curriculum enforced by the MEP is a comprehensive programme that ensures continued revision through small and logical steps, but with key aims of mastering each year. That is, rather than simply reviewing the same material until all pupils have it memorized, the spiral process allows for continual development to challenge the most able learners, while also continuing to visit earlier areas of knowledge for those who struggle with mathematics [26].

2.2.2. Subject Knowledge Enhancement Programmes—How Important Is the SKE in Preparing Teachers for the MEP?

SKE Pogrammes aid in improving teachers' subject knowledge, attitudes, understanding and confidence [27]. As put forward by French [28], subject knowledge, which embraces depth of understanding, an ability to think mathematically and subject-related pedagogical knowledge, as well as content knowledge at an appropriate level, is vitally important to all who teach mathematics. Ball, Thames and Phelps [29] endorsed this view when they posited that 'Teaching requires knowledge beyond that being taught to students' and teachers require what they call 'unpacked' mathematical knowledge, which they use to teach 'decompressed mathematical knowledge' to learners so that students eventually 'develop fluency with compressed mathematical knowledge'. It is, therefore, implied that teachers of mathematics must have sound technical mathematical knowledge beyond the scope of the grade level that they are teaching before they can effectively help their students develop an understanding of mathematical concepts within the teaching and learning discourse [28,29].

In rationalizing the need for implementing the MEP, Burghes [14] identified that too few teachers having adequate mathematical knowledge and understanding as one of the reasons for the continued difficulties faced in developing an education system that supports all pupils to reach their mathematical potential. Teachers' mathematical competency (mathematical subject knowledge) is a crucial aspect of success in improving mathematics in schools [14]. If the mathematical competence of teachers is an issue, then focus needs to be placed on mathematical concepts in a relevant and practical way [14]; one way to achieve this is through building teachers' subject knowledge. It was implied by Burghes [14] that teachers' mathematical competencies, (especially subject knowledge for teaching) is important for the effective implementation of the MEP.

2.2.3. The Impact of MEP on Mathematics Education

The MEP aims to equip children with the disposition to become good learners, inspiring them as mathematicians, questioning and challenging them to be logical thinkers and creating a safe environment where they can be confident enough to excel [30]. This view was endorsed by Burghes [14], who purports that the MEP supports children to raise their attainment and progress and provides them with opportunities to explore their own and each other's thinking. The MEP helps students to develop and display a positive attitude towards mathematics [14]. After the implementation of the MEP, students viewed the subject as interesting and one which was worth persevering with when they were challenged by a task [14]. Additionally, the MEP aids in getting pupils to be more engaged and see themselves as being successful learners of mathematics [15].

Studies have shown that the implementation of the MEP into mathematics classrooms has positively impacted the teaching and learning of mathematics [14]. Burghes [14] added that children's use of reasoning, thinking, and mathematical language is positively impacted by the MEP. Burghes [14] also indicated that the MEP positively impacted:

- The children's development and use of mathematical language;
- The children's analytical and logical thinking skills.

Based on the research done by Burghes [13], the MEP succeeded in raising students' understanding of basic mathematical concepts, which subsequently positively impacted their attainment in the subject.

3. Methods

3.1. Research Design

The design of this research was a quasi-experimental study.

3.2. Participants and Sampling Procedures

The sample for the intervention group consisted of 150 first-grade students and seven teachers from two primary schools in representative areas in Jamaica. The comparison group consisted of 50 grade one students and two teachers from one primary school in Jamaica. The participating schools from both groups broadly represent a typical Jamaican primary school. The average age of the participants from both groups was 6.5 years with an SD of 3 months. The participants of the intervention and the comparison groups were randomly selected from the country's first graders who were underperforming in mathematics and whose schools were not supported with coaching assistants. The schools that participated in both groups were all ranked as category 3 primary schools in Jamaica and served children from similar socioeconomic backgrounds. All the student participants were learning the grade standards in mathematics, established by the Ministry of Education, based on termly pacing guides. Additionally, the teaching experiences of the teachers of the intervention group ranged from 4 years to 16 years, while the teaching experiences of the teachers in the comparison group was 7 years and 13 years.

3.3. Procedures, Materials and Instruments

3.3.1. Procedure

Ethical approval was granted by University of Plymouth to carry out this research. The university's research protocols and ethical standards regarding privacy, confidentiality, anonymity, informed consent and data preservation were followed.

Prior to the implementation of the MEP, the teachers in the intervention group were trained in subject knowledge enhancement to ensure that they were equipped with the requisite content knowledge needed to implement the MEP. Additionally, training was conducted in the components of the MEP aimed at helping teachers develop the skill sets needed to effectively incorporate the MEP resources in their teaching and learning discourse. Throughout the intervention, quarterly continued professional development sessions were provided for the teachers. Each session was held at the respective participating schools and lasted for an average of two and a half hours, totalling approximately 12 h of training across the intervention. The sessions focused on lesson studies related to the MEP, best MEP practices, conquering the challenges associated with implementing the MEP, video presentations that highlights the key components of the MEP and teachers' reflections.

Prior to the intervention, the mathematics pre-test and pre-attitudinal survey were administered to both groups. Participants in the intervention group were then taught the Jamaican Grade One mathematics standards in lessons lasting 60 min, three times a week using the adapted and tailored MEP resources over the nine-month period (September 2017–June 2018). The students from the comparison group were taught mathematics using the traditional teaching methods employed across Jamaican primary mathematics classrooms. The teachers in this group used the Ministry of Education's assigned textbooks and resources in their daily practice. Following the intervention, the mathematics post-test and post-attitudinal surveys were administered to both groups.

3.3.2. Materials

The materials used for this study are the adapted MEP resources that were tailored to fit the Jamaican mathematics classroom setting. Once these resources were adapted, modifications were made to ensure that the resources were fully aligned to the Jamaican primary mathematics curriculum in terms of content, sequence, and language. Teachers were provided with support plans for each suggested lesson. Students were furnished with the MEP support materials, which included:

- Mathematics Reasoning Practice Books
- Number lines
- Number cards
- Shape cards

3.3.3. Instruments

Attainment Measure

To measure the impact of the MEP on students' attainment in mathematics, data were collected using the adapted MEP standardized tests. Test 0, which consisted of questions with a total of 10 marks, was administered as a pre-test and test 1 which consisted of the questions with a total of 20 marks (ten marks from test 0 and ten new marks) was administered as a post-test. Both tests were designed to test students' understanding of number concepts and basic operations with numbers. Test 0 and Test 1 were analysed using SPSS software, version 25. Students' attainment was compared using boxplots, mean difference and effect size. Chi- Squared tests were used to measure the association between progress scores and attainment.

Attitude Measure

To measure the impact of the MEP on students' attitude towards mathematics, data were collected using an attitudinal survey. This survey consisted of 10 questions which evaluated how students' viewed mathematics in terms of affection, difficulty, and relevance. The attitudinal survey is presented in Figure 1. The same attitudinal survey which applied a Likert three-point scale was given prior to and after the intervention. The pre- and post-test and the pre- and post-attitudinal surveys use comparative summary tables.

Children's Attitudinal Survey

Instructions: Read each statement carefully. Please circle your answer which is either no, unsure or yes.

Grade: ______________ Gender: Male or Female

1. a. I like mathematics	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	______________________		
2. I can learn mathematics	1 - No	2 - Unsure	3 - Yes
3. a. I like going to mathematics class	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	______________________		
4. Mathematics is interesting	1 - No	2 - Unsure	3 – Yes
5. My teacher makes mathematics fun	1 - No	2 - Unsure	3 – Yes
6. I enjoy doing mathematics	1 - No	2 - Unsure	3 - Yes
7. I do well in mathematics	1 - No	2 - Unsure	3 - Yes
8. a. Mathematics is hard for me	1 - No	2 - Unsure	3 - Yes
b. Why? (Give a reason for your answer)	______________________		
9. I will use mathematics in the future	1 - No	2 - Unsure	3 - Yes
10. Mathematics is important to my everyday life	1 - No	2 - Unsure	3 - Yes

Figure 1. Students' mathematics attitudinal survey.

4. Results

4.1. The Impact of MEP on Students' Attainment in Mathematics

The first research question was geared towards examining the effect that the implementation of the MEP in Jamaican mathematics classes would have on students' attainment in mathematics. To answer this question, the results from the pre-test and the post-test were analysed. The results are shown in the figures and tables below:

Figure 2 shows that, for the pre-test (test0), the intervention group has a median score of 5 and the comparison group has a median score of 6. This is an indicator that, for the pre-test, the median score of the intervention group is less than the median score of the comparison group. The range of score for the intervention group is 8 and the interquartile range is 3; while the range of scores for the comparison group is 6, the interquartile range is 3. That is, the pre-test score variability of the intervention group is greater than the comparison group. For the intervention group, the lower 25% of the scores lies between 1 and 4, the middle 50% of the test scores of the lies between 4 and 7 the upper 25% of scores lies between 7 to 9. For the comparison group, the lower 25% of the scores lies between 2 and 4; the middle 50% of the test scores lies between 4 and 7; the upper 25% of scores lies between 7 and 8.

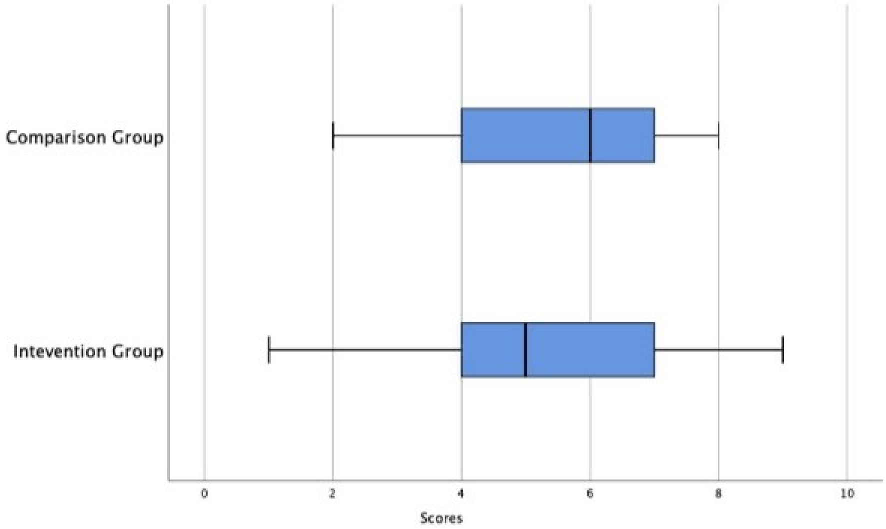


Figure 2. Double boxplots of results of pre-test (test 0) for intervention and comparison groups.

Figure 3 shows that, for the post-test (test1), the intervention group has a median score of 15 and the comparison group has a median score of 12. This is an indicator that, for the post-test, the median score of the intervention group is greater than the median score of the comparison group. The range of scores for the intervention group is 16 and the interquartile range is 6, while the range of scores for the comparison group is 17 and the interquartile range is 6. That is, the post-test variability score of the intervention group is less than the comparison group. For the intervention group, the lower 25% of the scores lies between 4 and 12, the middle 50% of the test scores of the lies between 12 and 18 the upper 25% of scores lies between 18 to 20. For the comparison group, the lower 25% of the scores lies between 1 and 8; the middle 50% of the test scores lies between 8 and 14; the upper 25% of scores lies between 14 to 18.

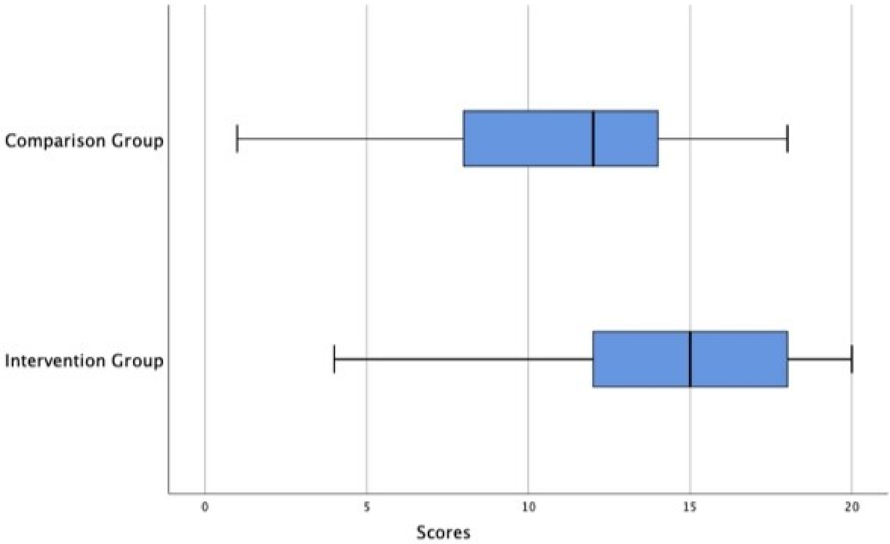


Figure 3. Double boxplots of results of post-test (Test1) for intervention and comparison groups.

The results of the Pearson Chi-Squared Test scores for the association between progress scores and groups was 23.4 with 3 degrees of freedom, which is statistically significant at the 0.05 level. This is represented in Table 2.

Table 2. Pearson Chi-Square tests showing the association between progress scores and the groups.

		Group
Progress	Chi-square	23.375
	Df	3
	Sig.	0.000

Table 3 reveals that the mean difference between the pre- and post-tests for the comparison group is 0.12 with a standard deviation of 2.64 and effect size of 0.045. As summarized in Table 3, the mean difference between the pre- and post-tests for the intervention group is 2.23, standard deviation is 1.84 and the effect size is 1.21. Based on Cohen's d convention, the effect size for the comparison group is small, since $0.045 < 0.2$ and, effectively, zero whereas the effect size for the intervention group is large, since $1.21 > 0.8$. Hattie's [31] synthesis of meta-analysis of interventions in the field of education found that the average overall effect size, using Cohen's d statistic was 0.4. Therefore, an effect size of 1.21 is well above average and can be considered to indicate a very substantial impact of the MEP intervention.

Table 3. Cohen's d effect size of the pre- and post-tests for each group.

Groups	Mean Difference	Std. Deviation	Effect Size
Comparison Group	0.12	2.64	0.045
Intervention Group	2.23	1.84	1.21

Based on the results presented in Figures 2 and 3 it can be concluded that the implementation of the MEP has had a substantial positive impact on students' attainment in mathematics. The findings presented in Tables 2 and 3 revealed that there is a significant association between progress scores and groups, indicating that the implementation of the MEP significantly impacted students' attainment in mathematics.

Additionally, the results of the ANCOVA (F (1, 197) = 53.9, p = 0.00] indicated a significant difference in post-test scores between the two groups after adjusting for the pre-test scores. The participants in the intervention group obtained higher scores on the post-test than those in the comparison group, with an effect size reported ($\eta^2 = 0.215$). Since Montgomery [30] has stated that the eta squared effect size cut off points are small = 0.01, medium = 0.06 and large = 0.14, an effect size of $\eta^2 = 0.215$ indicates a large effect size. The adjusted marginal mean post-test scores are displayed in Table 4.

Table 4. Adjusted marginal mean post-test scores.

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Comparison Group	5.664	0.245	5.180	6.148
Intervention Group	7.745	0.142	7.466	8.025

Covariates appearing in the model are evaluated at the following values: pre-test = 5.5200.

4.2. The Effect of the MEP on Students' Attitude towards Mathematics

The second research question was geared at examining how the MEP impacted students' attitude towards mathematics. To answer this question, the results from the pre and post student attitudinal surveys were analysed. The specific scale that applied to the attitudinal survey is: 1—no, 2—unsure and 3—yes.

Tables 5 and 6 show that students' attitude towards mathematics were positively impacted by the implementation of the MEP into Jamaican primary mathematics classroom. Higher percentage increases were observed in students' responses on items from the survey that addressed positive feeling towards mathematics in the intervention group. Evidence of this was noted with item 1 of the survey, where it was revealed that 10% more of the students from the intervention group indicated that they liked mathematics more after being exposed to the MEP, while there were no changes in the number of students who indicated that they liked mathematics in the comparison group. Similarly, 8% more of the students of the intervention indicated that they liked going to mathematics classes on the post-attitudinal survey, while 6% more students of the comparison group indicated that they enjoyed going to mathematics classrooms on the post-attitudinal survey. It was also noted that 6% less of the students in the intervention group found mathematics hard on the post-attitudinal survey, while 2% more of the students in the comparison group found mathematics hard on the post attitudinal survey.

Table 5. Pre- and post-students' mathematics attitudinal survey for the intervention group.

	Pre-Attitudinal Survey (%)			Post-Attitudinal Survey (%)		
	Yes	Unsure	No	Yes	Unsure	No
I like mathematics	35	23	42	45	21	34
I can learn mathematics	40	19	41	50	16	34
I like going to mathematics classes	40	19	41	48	19	33
Mathematics is interesting	32	26	42	37	31	32
My teacher makes mathematics fun	27	41	32	35	40	25
I enjoy doing mathematics	33	7	60	45	7	49
I do well in mathematics	37	18	45	37	27	36
Mathematics is hard for me	49	27	24	43	24	33
I will use mathematics in the future	54	0	46	59	0	41
Mathematics is important to my everyday life	49	2	49	56	7	37

Table 6. Pre- and post-students' mathematics attitudinal survey for the comparison group.

	Pre-Attitudinal Survey			Post-Attitudinal Survey		
	Yes	Unsure	No	Yes	Unsure	No
I like mathematics	36	14	50	36	18	46
I can learn mathematics	30	24	46	34	28	38
I like going to mathematics classes	30	10	60	36	8	56
Mathematics is interesting	30	16	54	32	18	50
My teacher makes mathematics fun	30	12	58	32	10	58
I enjoy doing mathematics	28	14	58	30	12	58
I do well in mathematics	30	18	52	30	20	50
Mathematics is hard for me	46	26	28	48	24	28
I will use mathematics in the future	38	20	42	54	14	32
Mathematics is important to my everyday life	46	6	48	46	6	48

The results obtained indicated that the implementation of the MEP into Jamaican Primary classrooms positively impacted students' attitudes towards mathematics. This was evident in the data collected, where it was observed that more students from the intervention group, when compared with the comparison group, responded 'yes' to questions that addressed positive attitudes towards mathematics after they were exposed to the MEP. For example, 10 percent more of the students from the intervention group indicated that they liked mathematics on the post attitudinal survey. Whereas, in the comparison group, there were no changes in the number of students who indicated that they liked mathematics on the post-attitudinal survey. Additionally, 6 percent less students in the intervention group indicated that mathematics was hard after they were exposed to the MEP, whereas in the comparison group, two percent more students indicated that mathematics was hard on the post attitudinal survey.

5. Conclusions

Study findings showed that the implementation of the MEP in Jamaican primary classes had a substantial positive impact on students' attainment in mathematics, as indicated by an effect size of 1.21, based on Cohen D's convention of effect size, whereas the comparison group was found to have a near-zero effect size of 0.045. This large effect size was confirmed by the analysis of covariance, which found the eta squared effect size to be large ($\eta^2 = 0.215$). This finding is supported by prior research on the MEP, which indicated that performance in mathematics is positively impacted when the MEP is integrated into Mathematics classes [13,14]. Additionally, enrichment programs, such as the MEP, have been found to help deepen students' mathematical understanding [22], which subsequently aids in improving performance in mathematics [23,24].

The findings also showed that the use of the MEP resources to teach mathematics positively impacted students' attitude towards mathematics. The results of the post-attitudinal survey indicated that more students from the intervention group indicated that they liked mathematics, enjoyed going to mathematics class and thought mathematics was fun after they were exposed to the MEP. Additionally, after being exposed to the MEP, less students thought that mathematics was difficult. This is an indicator that students' disposition and attitudes towards mathematics were positively impacted by the implementation of the MEP. The findings of this research are supported by previous research, which indicated that the MEP helped students to develop and display positive attitudes towards mathematics [14]. A previous study, conducted by Burghes [14], also indicated that, after the implementation of the MEP, students viewed mathematics as being an interesting subject and one which was worth persevering with when they were challenged by a task.

6. Limitations

This study examined the impact of the MEP on Jamaican students' attainment in and attitude towards mathematics. Limitations to this study included having a small sample size, particularly for the comparison group, and the duration of the intervention. The comparison group only consisted of two classes, while the intervention group had seven classes. Comparisons were, however, made between the different intervention and comparison groups. Significant mean differences were obtained between the pre- and post-tests on mathematics performance in the sample group. The number of students in the intervention and comparison groups was not the same, which may have affected the validity of the differences obtained. The impact of the MEP on student attainment in mathematics would have been more valid if the study lasted beyond longer than nine months and if MEP resources were used for all mathematics lessons. Additionally, although teachers were observed weekly, there were no other measures in place to ensure that the teachers were implementing the MEP with fidelity when not being observed. Additionally, the impact of the MEP on Jamaican primary mathematics would have been more valid if its impact was compared to another intervention that was implemented for the same amount of time. Therefore, future research on the impact of the MEP and similar initiatives on Jamaican Primary mathematics is necessary.

Author Contributions: Conceptualization, S.K.K.B.-T. and D.B.; Data Curation, S.K.K.B.-T.; Formal Analysis, S.K.K.B.-T.; Funding acquisition, D.B.; Methodology, S.K.K.B.-T.; Project administration S.K.K.B.-T.; Resources, D.B., Supervision, G.H., and D.B.; Validation, G.H. and D.B.; Writing—original draft S.K.K.B.-T.; Writing—review & editing, G.H. and D.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by The Centre of Innovation in Mathematics Teaching (CiMT, University of Plymouth, UK.

Institutional Review Board Statement: This study was conducted according to the guidelines of the University Research Ethics Committee (UREC) and approved by University of Plymouth's Education Research Ethics Sub-committee, with approval number 17/18-209.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data are not publicly available due to privacy restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Murphy, X. An Overview of Jamaica, the Island and People. Available online: https://jamaicans.com/fact/ (accessed on 5 December 2020).
2. Dagnini, K.J. The importance of Reggae Music in the Worldwide Cultural Universe. Available online: https://journals.openedition.org/etudescaribeennes/4740?lang=en (accessed on 17 March 2021).
3. Franklyn, D. Sports in Jamaica: A Local and International Perspective. Available online: http://gracekennedy.com/lecture/GRACE-Lecture-2010.pdf (accessed on 23 March 2021).
4. Education in Jamaica. Available online: https://www.studycountry.com/guide/JM-education.htm (accessed on 17 December 2020).
5. Jamaica History & Background. Available online: https://education.stateuniversity.com/pages/725/Jamaica-HISTORY-BACKGROUND.html (accessed on 10 October 2020).
6. Tyson, E. Education Then and Now. Available online: http://jamaica-gleaner.com/gleaner/20120805/cleisure/cleisure4.html (accessed on 23 December 2020).
7. Kirton, C.; Ferguson, J. An Overview of the Economy of Jamaica. In *Jamaica Debt and Poverty*; Oxfam GB: Oxford, UK, 1992; Available online: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/123007/bk-debt-poverty-jamaica-part-ii-010192-en.pdf;jsessionid=16B8CD7DE783850B1470F1445DD577AD?sequence=23 (accessed on 26 September 2020).
8. Hastings, J. Jamaica Takes Big Steps Towards Improving its Educational System. Available online: https://www.worldbank.org/en/results/2015/09/16/jamaica-big-steps-improving-educational-system (accessed on 10 October 2020).
9. Vision 2030 Jamaica. National Development Plan. Available online: http://www.vision2030.gov.jm/Portals/0/NDP/Vision%202030%20Jamaica%20NDP%20Full%20No%20Cover%20(web).pdf (accessed on 22 August 2020).

10. Ministry of Education. National Mathematics Policy Guidelines. Available online: https://moey.gov.jm/sites/default/files/National%20Mathematics%20Policy%20Guidelines%20(2013).pdf (accessed on 7 July 2019).
11. Buddo, C. Mathematics Education: A Case for Problem Solving. Education Matters. Available online: http://www.jamaicaobserver.com/columns/Mathematics-education--A-case-for-problem-solving_90150 (accessed on 15 March 2019).
12. Government of Jamaica, Ministry of Education Youth and Information. Statistics—Varying Articles. Available online: https://www.moey.gov.jm/statistics (accessed on 17 June 2019).
13. Burghes, D. *Mathematics Enhancement Programme: The First 3 Years*; University of Exeter, Centre for Innovation in Mathematics Teaching: Exeter, UK, 2000. Available online: https://www.cimt.org.uk/projects/mep/intrep00.pdf (accessed on 1 September 2018).
14. Burghes, D. *Enhancing Primary Mathematics Teaching and Learning*; CfBT Education Trust: Reading, UK, 2012; pp. 33–35, 45–82, 97–104.
15. Mohamed, L.; Waheed, H. Secondary students' attitude towards mathematics in a selected school of Maldives. *Int. J. Humanit. Soc. Sci.* **2011**, *1*, 77–281.
16. Nicolaidou, M.; Philippou, G. Attitudes towards mathematics, self-efficacy and achievement in problem solving. In *European Research in Mathematics Education III*; Mariotti, M.A., Ed.; University of Pisa: Pisa, Italy, 2003; pp. 1–11.
17. Sanchez, K.; Zimmerman, L.; Ye, R. Secondary students' attitudes toward mathematics. *Acad. Exch. Q.* **2004**, *8*, 56–60.
18. Eshun, B. Sex-difference in attitude towards mathematics in secondary schools. *Math. Connect.* **2004**, *4*, 1–13. [CrossRef]
19. Zan, R.; Martino, P. Attitude toward mathematics: Overcoming the positive/negative dichotomy. In *Beliefs and Mathematics*; Sriraman, B., Ed.; The Montana Mathematics Enthusiast: Monograph Series in Mathematics Education; Age Publishing: Charlotte, NC, USA; The Montana Council of Teachers of Mathematics: Charlotte, NC, USA, 2008; pp. 197–214.
20. Hynes, K.; O'Connor, S.; Chung, A.M. *Literacy: Exploring Strategies to Enhance Learning in After-School Programs*; Wellesley College Center for Research on Women: Boston, MA, USA, 1999.
21. Schacter, J. *Reducing Social Inequality in Elementary School Reading Achievement: Establishing Summer Literacy Day Camps for Disadvantaged Children*; Milken Family Foundation: Santa Monica, CA, USA, 2001. Available online: http://www.mff.org/pubs/reading_camp_study2001.pdf (accessed on 20 June 2020).
22. Johnson, D.T.; Sher, B.T. *Recourse Guide to Mathematics Curriculum Materials for High-Ability Learners in Grades K-8*; College of William and Mary, Center for Gifted Education: Williamsburg, VA, USA, 1997.
23. Alzoubi, S.M. Effects of Enrichment Programs on the Academic Achievement of Gifted and Talented Students. *J. Educ. Young Sci. Gift.* **2014**, *2*, 22–27.
24. Wiggins, H.; Harding, A.; Engelbrecht, J. Student enrichment in mathematics: A case study with first year university students. *Int. J. Math. Educ. Sci. Technol.* **2017**, *48* (Suppl. 1), S16–S29. [CrossRef]
25. Kim, M. A Meta-Analysis of the Effects of Enrichment Programs on Gifted Students. *Gift. Child Q.* **2016**, *60*, 102–116. [CrossRef]
26. McAleavy, T. Exploring Approaches to Teaching Primary Maths. Available online: https://www.theguardian.com/teacher-network/2012/jul/20/primary-maths-programme (accessed on 16 February 2021).
27. Stevenson, M. 'Profound understanding of fundamental mathematics': A study into aspects of the development of a curriculum for content and pedagogical subject knowledge. *Proc. Br. Soc. Res. Learn. Math.* **2008**, *28*, 103–107.
28. French, D. Subject Knowledge and Pedagogical Knowledge. Available online: http://www.maths.manchester.ac.uk/~{}avb/pdf/DougFrenchSubjectKnowledge.pdf (accessed on 10 October 2019).
29. Ball, D.; Thames, M.; Phelps, G. Content Knowledge for Teaching: What Makes It Special? *J. Teach. Educ.* **2008**, *59*, 389–407. Available online: https://www.academia.edu/28835113/Content_Knowledge_for_Teaching_What_Makes_It_Special (accessed on 1 January 2021). [CrossRef]
30. Montgomery, D.C. *Design and Analysis of Experiments*, 8th ed.; John Wiley and Sons: Hoboken, NJ, USA, 2012.
31. Hattie, J. *Visible Learning: A Synthesis of over 800 Meta-Analyses Relating to Achievement*; Routledge: London, UK, 2009.

Teacher subject knowledge for enhancing learners' mathematical thinking

Shandelene Binns Thompson

Abstract

Jamaica seeks to develop an education and training system that produces well-rounded and qualified individuals who will be empowered to learn for life, able to function as creative and productive individuals in all spheres of society and be competitive in a global context. This vision of Jamaica is however hampered by the under-achievement in Mathematics that now challenges the nation's schools. This starts in the primary sector of education. Primary teachers of mathematics need to have a sound knowledge of mathematical concepts and appreciate the foundations needed for higher study. Here the author shows that subject knowledge enhancement can help teachers obtain that higher level understanding of mathematics to help them become more effective teachers of mathematics; this is a necessary starting point of a long-term strategy for enhanced mathematical progress for developing countries.