An Evaluation of a Math Specialist Teacher Pilot Program: A Mixed Methods Study

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Abstract

This mixed methods case study utilized the conceptions of a program evaluation to investigate the Primary Mathematics Specialist Teacher Professional Development pilot project, to provide clarity on the implementation, and to inform the program manager, the Ministry of Education, and school leaders of the effectiveness of the professional development. The researcher utilized five different instruments to collect data including test scores, observation protocols, interviews, field notes and document review. Participants in this study represented a multi-level sampling approach.

The findings indicated that administrators, coaches and teachers perceived the implementation of the professional development as positive and appeared to improve students' skills to learn mathematics in all four schools. Furthermore, teachers valued and appreciated the support from coaches as they expressed how they fostered a professional relationship where collaboration was heightened through coteaching, modelling, dialogue, feedback, and common planning. The overall benefit of the professional development was significant as teachers changed their beliefs about mathematics practices which further enhanced students' interest, confidence, and participation and holds promise for the future of the schools and effect on student learning. However, if teachers were more involved in professional development decisions and their needs and interest were considered, the results would have been more positive. The findings from this study support previous research that utilized the transformative learning theory to investigate adult learning. Given the pilot status of this implementation, these findings offer in sight to initiate discussion between the Ministry of Education and the program manager to expand the program to other schools.

Dedication

This dissertation is lovingly dedicated to my father, the late Benaldo Daley, and my siblings the late Earl and Beverley Daley.

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Chapter I: INTRODUCTION

Over the past two decades a growing concern has been placed on school improvement. The high demand on the education system for accountability globally requires the development of a practice of continuous school improvement. Such practice, according to Elmore (2014) is the wisdom and discipline about how to increase the quality of instructional practice to positively impact student learning in classrooms and for it to reach the entire school system. Teachers' essential role in school and their knowledge of their subject matter are crucial for improvement in the quality of instruction (Hill & Ball, 2004). Continuing development and learning of teachers is key to improving U.S. schools (Borko, 2004; Darling-Hammond, 1998; Desimone, 2011; Elmore, 2014). Teachers must be consistently effective in facilitating the learning process while overcoming the challenge of complex material and diverse students (Darling-Hammond, 2006; Darling-Hammond & McLaugh, 1995). The concern, however, is that teachers need support from the teaching profession for continual learning which is the likeliest way to encourage positive improvements in student learning (Darling-Hammond, 1998). According to Remillard (2005), teachers need to know about curriculum resources and technologies in order to connect their students with sources of information and knowledge that will enhance their skills in finding and synthesizing information as well as in problem-solving.

Decades of professional development studies focused on teacher satisfaction, attitude change, or commitment to innovation, rather than the results or the processes that make it work (Desimone, 2011). Growing tension among educational researchers stresses the restructuring of the approach to professional development as they believe that change will always fail without infrastructures and processes that engage teachers in developing and applying new knowledge, skills, and understandings (Darling-Hammond and McLaugh, 1995; Elmore, 2014; Fullan,

2015). Darling-Hammond and McLaugh (1995) suggested that designers of professional development should provide the leap for teachers from theory to practice. They claimed that the traditional top-down teacher training strategies cannot work. Teachers need opportunities to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy, and student needs.

This study evaluated the professional development for the Primary Mathematics Specialist Teacher pilot program in Jamaica. This evaluation utilized Guskey's (2000) framework to evaluate professional development with the integration of Joyce and Showers' (2002) concept of effective professional development.

Problem Statement

Teachers in mathematics education were expected to effectively teach new and challenging mathematics to diverse populations using research-based strategies. Shulman (1986) indicated that mathematical and pedagogical content knowledge are integral parts of effective mathematics instruction. Students' achievement in mathematics has been an ongoing discussion throughout the United States (Gerreston, Bosnick & Schofield, 2008). Akkus (2016) indicated that only 26% of 12th grade students were able to reach the threshold of expertise in mathematics required by National Association of Education Procurement. Jamaica has been grappling with low mathematics performance for more than a decade despite efforts by the Task Force on

Educational Reform Jamaica (2004) that addressed governance and management, curriculum, and teaching. The results of mathematics performance on national assessments in 2003 revealed 48% as the average score in Grade Six Achievement Test (GSAT) and 3.8 % of the students mastering all five mathematics subtests in the Grade Three Diagnostic Tests. The Task Force on Educational Reform in Jamaica urged the nation to implement a "transformation path" aimed at a shared vision (Task Force on Educational Reform Jamaica, 2004). The Jamaican Ministry of Education revealed in 2013 that less than 20% of a given secondary cohort left the formal education system with adequate mathematics qualifications to access opportunities. Evidently all levels of the education system delineate the lack of mathematical understanding resulting in low achievement in the subject (Ministry of Education, 2013).

The Ministry of Education established the National Comprehensive Numeracy Program in 2011 deployed mathematics coaches in schools to boost the mathematics performance. The National Standard Curriculum (NSC) was implemented in 2016 based on a set of subject areas that forms the content, with problems presented to be explored through methods that are student centered (Morgan, 2016). The National Standard Curriculum was framed in constructivist learning as it was the theory underpinning the values and principles upon which the curriculum rests (Morgan, 2016). The Jamaican education system was a "generalist" teacher approach in which one teacher is deployed to a group of students to teach all core subject areas.

The National Standard Curriculum required that teachers be equipped with the knowledge and competencies to facilitate students in gaining literacy and numeracy skills to efficiently access secondary education. The *Primary Specialist Teacher Model* was proposed by the Ministry of Education Youth and Information. Jamaican teachers acquired in-service training in 2018 for mathematics and science or language arts and social studies.

Efforts to improve mathematics instruction frequently rely on teacher professional development. Considerable resources were invested in the professional development workshops in Jamaica, however, to date no systematic study of the mathematics program has been done. It was critical to evaluate the mathematics program to determine if the intended outcomes of the program were achieved.

Purpose

The purpose of this study was to utilize the conceptions of program evaluation to investigate the Primary Mathematics Specialist Teacher Professional Development pilot project, to provide clarity on the implementation, and to inform the program manager, the Ministry of Education, and school leaders of the effectiveness of the professional development. was to determine the impact of the implementation of the Primary Specialist Teacher Model for mathematics in four primary schools in Jamaica. This study aimed to provide insight about the mathematics pilot project to the program manager, the Ministry of Education, school leaders,

teachers, and mathematics coaches. The study intended to investigate teacher perceptions of the mathematics pilot project to make informed decisions about professional development.

Role of Theory

Transformative learning theory was the framework for which this research was guided. Transformative theory is a valuable frame to investigate adult learning (King, 2004) that focuses on teacher change. The researcher sought to conduct an evaluation of the Primary Specialist Teacher Model mathematics professional development. Guskey's (2000) framework of professional development and transformative learning theory were used for developing the evaluation questions and the instruments in this study.

Using a transformative lens, the theory of change that underpins the program was used to evaluate the Primary Specialist Teacher Model professional development mathematics component in the program evaluation. Student mathematics scores for two pilot tests were examined to determine if there was a growth in student academic performance during the implementation of the professional development. The observational checklist was also used to determine if teaching techniques and strategies taught in the professional development training were seen in the classroom. Interview data were collected from teachers, coaches and administrators to understand how teachers viewed the training, how they responded to the

training and the effects they believed the training had on student performance. Documents provided data on the program to determine how the implementation was done.

Research Questions

1. What are teachers' perceptions of the Primary Specialist Teacher Model mathematics professional development?

2. What are teachers' perceptions regarding their use of the Primary Specialist Teacher Model mathematics professional development in the classroom?

3. What changes are evident as a result of implementing the Primary Specialist Teacher Model mathematics professional development?

4. What are teachers' perceptions of students' use of mathematics skills from the Primary Specialist Teacher Model mathematics professional development that evidence implementation of the National Standard Mathematics Curriculum?

5. Mathematics Professional Development of the NSC adopted eight mathematics teaching practices for instructional strategies and approaches. Did these approaches promote students learning mathematics as measured by (1) cooperative learning, (2) reasoning and problem solving, (3) posing purposeful questions, and (4) activity based learning?

Description of the Program

The 5-year report from the National Education Inspectorate (NEI) on school inspections that ended March 2015, called for greater attention to teaching instruction. The data revealed that in the area of teaching and learning a significant number of primary and secondary schools were rated as "unsatisfactory" and "needed additional support." Consequently, the Ministry of Education, Youth and Information (2018) recommends the deployment of the subject specialists at the primary level as a strategy to improve teacher quality and to improve student performance.

The Ministry of Education, Youth and Information in Jamaica conducted the Primary Specialist Teacher Model Pilot Summer Training Workshops in 2018. The in-service training for teachers was conducted at 40 primary schools with specialist in mathematics and science or social studies and language arts. The residential workshops were held at the University of the West Indies on July 9-16th, 2018. Teachers were redeployed by their school administrators into mathematics and Science or Language Arts and Social Studies to undertake the professional development. Training was fully funded by the Ministry of Education, Youth and Information. The Specialist Teacher Model in Jamaica defined staff as generalist teachers with in-depth and specific knowledge of two core subjects (Ministry of Education, Youth and Information, 2018). The Ministry of Education created this model based on the Singapore Primary Education Model relative to the dual subject specialization (2018).

The goals of the specialist teacher professional development included building sustained and continued improvement in teacher capacity in teaching instructions of core subject areas, increasing the number of well-structured lesson plans, improving student attainment and improving school management. The objectives of the pilot were to augment teachers' delivery of exploratory core areas (mathematics language arts, science, and social studies), improve student attainment in exploratory core subject areas, bolster the opportunity of targeted, capacity building opportunities for teachers and principals in primary schools and strengthen human resources in those schools.

This study focused on mathematics in the professional development program. Training for primary mathematics specialist teachers in grades 4-6 consisted of fifteen hours, covering five units in one module over four days. The professional development used the NSC mathematics performance standards to create instructional strategies, and develop lesson plans and learning activities.

Chapter II: LITERATURE REVIEW

Theoretical Framework

Transformative or transformational learning (terms used interchangeably in the literature) theory "shapes people; they are different afterward, in ways both they and others can recognize" (Clark, 1993, p. 47). In the field of adult education, it has become the most studied and most written about adult learning theory (Merriam, 2017; Taylor, 2007) since Knowles' proposal of andragogy in the 1970s. Like andragogy and self-directed learning, transformative learning theory is characterized as a form of learning engaged in by adults with an educator as the main architect of the theory. Conversely, transformative learning theory focuses on the cognitive process of meaning making not on learners' characteristics (Merriam, 2017). It has brought a new and intriguing identity (Taylor & Cranton, 2012) that is uniquely adult, abstract and idealized, grounded in human communication (Taylor, 2012) and has emerged as a valuable frame to investigate adult learning (King, 2004). Concisely, Christie, Carey, Robertson, and Grainger (2015) articulated that it accounts for how adult learners make sense of their experience which can be influenced by various structures that are modified to accommodate changes if the learners find them to be dysfunctional.

Jack Mezirow, an American sociologist, is credited with originating the theory of transformative learning after his groundbreaking study on the experiences of women who

returned to school to prepare for jobs. He found that this experience caused the women to examine their assumptions about who they were and how they were products of sociocultural expectations of women at that time (Mezirow, 1978). Mezirow (1978) uncovered that for adults returning to study often lead to "consciousness raising" and the process tended to take place sequentially through ten steps: (1) disorienting dilemma, (2) self-examination, (3) sense of alienation, (4) relating discontent to others, (5) explaining options to new behavior, (6) building confidence in new ways, (7) planning a course of action, (8) knowledge to implement plans, (9) experimenting with new roles, and (10) reintegration.

Later, Mezirow (2006) explained transformational learning as the process by which we transform problematic frames of reference (mindsets, habits of mind, meaning perspectives) or sets of assumption and expectation to make them more inclusive, discriminating, open, reflective and emotionally able to change. A frame of reference includes cognitive, conative and emotional components. It comprises two dimensions: habits of mind and a point of view. Habits of mind are more durable than points of view as points of view are subject to constantly changing as we reflect and identify a reason to change or revise assumptions. Transformation of our frames of reference is through critical reflection on the assumptions upon which our interpretations, beliefs and habits of mind or points of view are derived. There are different processes of learning and different forms of learning. Transformation has four processes of learning: (1) to elaborate an existing point of view, (2) to establish new points of view, (3) to transform our point of view and

(4) to transform our habit of mind by becoming aware and critically reflective of our own biases (Mezirow, 1994). Thus, the theory is positioned in the constructivist worldview. Further, transformations can be epochal or incremental (objective or subjective) (Mezirow, 2009). Objective reframing is critical reflection of assumptions other than through problem solving while subjectivity may involve self-reflection in challenging old perspectives resulting in transformation (Mezirow, 2009). In accordance "learning is understood as the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (Mezirow 1996, p. 162). Clearly, transformative learning refers to epistemology of adult learning, how adults reason and form their conclusions and beliefs.

Based on Habermas's three kinds of knowledge: instrumental, communicative (Mezirow, 2009) and emancipatory (Cranton, 2002: Taylor, 2008) transformative learning theory forms part of that framework (Kreber & Cranton, 2000). Communicative knowledge is derived from language, critical reflection and engaging in dialogue for validation. Of such, the acquisition of communicative knowledge is integral in the study of human relations in the different contexts such as education (Cranton, 2002). Communicative knowledge is less amenable to empirical tests compared to instrumental learning which relies on empirical testing. Discourse is dialogue devoted to assessing reasons presented in support of competing interpretations by examining evidence, arguments and other points of view critically (Mezirow, 1997). From dependable

interpretation or synthesis, a common understanding holds until new evidence or arguments appear. Dialogue is central to transformational learning, as it reflects an effort to reach consensus (Merriam, et al. 2007). Dialogue interrelates with critical reflection and engages at least two persons which Mezirow (2009) coined as dialectical and critically reflective thinking that leads to a likely judgement. More complex than daily conversations, it affirms truth or appropriateness of claims or validate the credibility of the facilitator (Mezirow, 1991; Taylor, 2009). However, the ideal conditions are necessary to accommodate such processes, for example having equal opportunity to participate in the various roles of discourse (Mezirow, 1994).

Cranton (2002) believed that emancipatory knowledge is communicative knowledge and can be a goal in all facets of adult education. Similarly, Paulo Freire's idea of transforming education was about social change. Freire (1970) rejected the 'banking concept' approach in education. Freire claimed that dialogue is critical for transformation. Freire purported that authenticity must be paramount in any dialogue that is to transform the world through true praxis giving every man his right to encounter dialogue (1970). Such dialogue he claimed must be a partnership in which the dialoguers (educators and students) attempt to learn together about the world and reality. Thus, this approach seeks to liberate the oppressed, causing a united reflection and action by the dialoguers embracing involvement, love, humility, faith, trust, democracy, hope and engagement in critical thinking. Such social endeavor promotes autonomous thinkers, a pivotal concept in Mezirow's personal transformative theory. Although Freire (1970) and

Mezirow(1994, 1997, 2000) found common grounds in the context of teaching and learning that necessitated for instance the facilitator model, peer collaboration and supportive relationship Mezirow (1994) viewed Freire's contribution as an educational philosophy not an attempt to develop an adult learning theory. Other divergent conceptions and interpretations of transformative learning theory are evolving in the field for instance, holistic, extrarational, integrative emancipatory, cognitive developmental and spiritual-integrative perspectives (Merriam & Bierema, 2014).

Critical Reflection

Merriam (2017) affirmed that the ten-step process of transformative theory still holds in framing current research. In fact, Merriam, Caffarella, and Baumgartner (2007) refined the ten-step transformational learning process into four key elements: experience, critical reflection, reflective discourse (Taylor, 2009) and action. While there is interdependence among the elements of transformative learning theory, critical reflection as a core component is relevant to the mathematics professional development.

Through adult education an organized effort is made to assist learners to take responsibility for their actions and acquire or improve their understanding, skills, and dispositions (King, 2004). Learners must become critically reflective according to Mezirow (1991, 2000, 2009) who believed this autonomous learning is a sense of self-empowerment

rather than uncritically acting on interpretations and beliefs of others. Transformative theory describes how adults integrate new information, perspectives, or practice into their world view as they engage in learning. When learners engage in opportunities to reflect on the meaning of what they are learning, they assess familiar or cherished values, beliefs, and assumptions. Such experiences can result in reconfirming their current perspectives or developing new way of understanding. It is within this experience of having the self-confidence to act on reflective insights (Mezirow, 2000) and making the shift from their deeply anchored frame of reference that transformative learning appears. This conative dimension of transformative learning relies on others and patterns of relationships and power.

Mezirow explained learning as a process of gaining new insight from an experience, which leads to understanding, acceptance and action (2009). In line with this, critical reflection and discourse are part of adult learning processes involving socio-cultural experience that requires persons to be decisive on their own (Mezirow, 1994). When new meaning perspectives is encountered our worldview is redirected. Notable epistemic, sociocultural, and psychic distortions occur through critically reflective assessment resulting in meaning perspectives. Reflection enables us to revise distortions in our beliefs and errors in problem-solving but critical reflection is an important function in transformation to critique the presuppositions on which our beliefs have been built (Mezirow, 1991, 1994). Very importantly, the nature of adult learning or education is the cardinal role played by these habits in making meaning (Mezirow, 1997). Taylor

(2009) reinforced that critical reflection is an essential element in fostering transformative learning. He later distinguished it as a theoretical construct and reflective practice (2017). Taylor emphasized that critical reflection is a unique attribute of the adult learning that can be termed as examining the integrity of deeply held beliefs based as result of experience (2009). Critical reflection is also associated with mature cognitive development (Merriam, 2004).

There are different ways to reflect whether on the content of the problem, the process of the problem-solving or premise of the problem (Taylor, 2009). Simply put, premise is an advanced level of problem solving that allow critical reflection to result in learning. Cranton identified critical reflection as an assessment of our beliefs and assumptions in order to obtain validity in the event of new experiences or knowledge, considering their sources, and examining underlying premises (2002). Thus, the concern is not about 'how' or the action rather the focus in critical reflection is on "why" and the reasons as well as the consequences for our actions. Similarly, when Kreber (2004) used content, process and premise to provide the levels of reflection that equate to the three domains of teaching knowledge (instructional, pedagogical and curricular) the conclusion was that for meaningful engagement it is important for teachers to focus on why they teach instead of what or how they teach.

In critical reflection, exchanging thoughts and ideas or engaging in discourse and receiving support are beneficial (Cranston, 2002). Integral to critical reflection are roles of

relationships, insight, intuition, emotion, and personality (Taylor 2017). Fundamentally, critical self- reflection offers the most profound learning when it is of premises about oneself assessing deeply our own belief system (Mezirow, 1994; Taylor, 2017). For teaching and learning critical reflection increases a kind of understanding of self and others so that teachers can engage in transformative learning. However, it is necessary to ensure that a learner-centered teaching approach is fostered where the teacher is a facilitator and power is balanced.

King noted that critical reflection is complex, but she accentuated critical reflection as centrality for professional development granting educators address context and condition and learners' experience and diversities for perspective transformation experience (2004). Seemingly, it is an on-going process in which teachers assess and reflect on their actions focusing on why they did it, what works and why they believe it is important (Beavers, 2009).

Brookfield (2015) identified critical thinking as teaching that is contextually informed which is one of four key assumptions of skillful teaching. Stephen Brookfield viewed the process of researching and identifying our assumptions to maintain accuracy and validity for the students and the content we teach as critical reflection (2015). Correspondingly, teachers assess comprehensibility, truth, appropriateness or authenticity of what is being asserted in innovations or teaching approach (Mezirow, 1991, Taylor 2008). Accuracy of our actions and assumptions are affirmed in four complementary ways— the lenses of students' eyes, colleagues' perceptions,

literature, and our own autobiography (Brookfield, 2015). First, through research techniques and our knowledge of student cognitive development we understand what they are thinking as a result we know our classrooms. Second, social interaction such as active participation and collaboration in professional development, peer teaching or other forms of dialogue teachers construct and share ideas and reach consensus. For this reason, transformative learning theory is linked to constructivist assumptions (Mezirow, 1994). Furthermore, Freire's (1970) social change is realized in this context.

Third, delving into the literature for new knowledge to foster the process. Finally, as learners reflecting on our autobiographies, we improve our teaching practice and how we act in the world. Taylor suggested that writing can enhance critical reflective practice as it facilitates learners in verbally articulating reflective thoughts and recording them for their reflections as well as to be shared with others (2009). An individual's transformative learning makes a "paradigm shift" since it leads to a shift in an adult's meaning perspective once such an adult engages in interactive activities that enhance his/her own worldview (Taylor, 2007). Based on the primacy of adult learning where one becomes critical reflective and has a new view of the world it is possible for social change as the person engages with the world. This indicates that when teachers are transformed it is likely that they will encourage and foster transformation in others (Christie et al.) and emancipatory transformative learning (Taylor, 2008) is possible

Empirical Findings from Studies on Transformative Learning Theory

The empirical evidence of transformative theory in the field of professional development is limited. All the studies reviewed gave profound attention to critical reflection as a fundamental element in transformative learning theory in gaining understanding of the topic being studied.

A critical analysis involving 40 peer-reviewed studies from 1999 to 2005 on findings and insights on transformative learning theory was conducted by Taylor (2007). Almost a decade earlier Taylors' (1998) review of the theory indicated that most of the research confirmed the centrality of critical reflection, a disorienting dilemma as a catalyst for change, and many of the phases of Mezirow's transformative process. However, greater attention was deserving in areas such as the role of context, the varying nature of the catalysts of transformative learning, the role of other ways of knowing, the importance of relationships, expanding the outcome definition of a perspective transformation and to a great extent its applicability as a guide for classroom teaching. In 2007, Taylor found that qualitative research design continued as the leading method of inquiry however longitudinal designs, action research, scales, surveys, content analysis of various documentation surfaced. The most significant change found was that greater attention was given to the practice of fostering transformative learning in the higher education classroom or a workshop setting. The studies covered a variety of areas including professional development of faculty and administrators. Also, the studies confirmed and deepened understanding of

previous finding as they identified the importance of providing direct and active learning experiences, the accessible medium for fostering transformative learning, the importance of 'pedagogical entry and the nature and the centrality of support when fostering transformative learning.

Very recently, Taylor (2017) conducted another review of 29 empirical studies from 2001-2016 focusing on Mezirow's conception of critical reflection. The purpose was to provide a more in-depth understanding of transformative learning theory its essential components. Taylor highlighted five themes from the review: the need for a critical reflection standard, journaling and critical reflection, quantitative assessment and critical reflection emotions and critical reflection, and the practice of critical reflection (2017). Based on the findings Taylor concluded that for a fundamental construct of transformative learning theory the challenges are numerous, he believed that it is has been established long enough for the refinement of its meaning, assessment and role in transformative learning theory (2017).

Christie et al. in a study that attempted to test if transformative learning theory can be put into practice in staff development and teacher education revealed that three case studies raised awareness and set in motion disorienting dilemmas that lead to transformative learning. Their position is that transformative learning is to bring adults to an awareness of their actions as a result of challenging current assumptions, to change for better. The authors conducted three case

studies in adult education. The first case replicated Mezirow's (1978) study of the matured age women college experience. In another case, anonymous values survey in workshops aimed at increasing learners' awareness of the ways in which they see the world, explained how disorienting dilemmas could trigger changes in one's attitudes, beliefs and values. The third case focused on a professional development program of an ongoing action research project that transformed the learners teaching practices and epistemological perspectives. The findings showed that learners became conscious of viewing the world, and causal and prescriptive assumptions they held that determined if they were valid. Christie et al. suggested that as a model for critical awareness course workshop embedded in action research projects underpinning transformative theory with critical and analytical reflection is viable. The conclusion was that if students are more critically aware transfer of knowledge is possible to suit their needs in context. They further concluded that critical analysis of assumptions can possibly change individuals' beliefs and the behavior within a field then, the field is very likely to change.

In 2004, King conducted a mixed method research that explored learners' experiences and investigated professors' viewpoints and teaching experiences and professional development practices and responsibility through the lens of transformative learning. Her study revealed the experiences of 58 adult educators from different groups spanning 4 years and the transformation in perspectives which some of them experienced while enrolled in graduate education courses with the same professor. King (2004) claimed that nature of change among adult learners was

pivotal in this continuing professional development that focused on integrating their learning and professional experience and engaging them in critically reflecting on their work. Survey and interview were used to collect data. From the analysis of the data using descriptive statistics, constant comparison and content analysis the findings showed the changes the learners experienced depicted that transformative learning that was fostered. Several recommendations were developed from the study concerning learners and teacher's responsibility to foster transformative learning. King (2004) suggested that teachers need to be reflective practitioners themselves and that learners need to be actively engaged in their learning and be provided with the environment that accommodates and encourages critical reflection. Further, some major suggestions were made for future research for educators and researchers in ways to expand the knowledge on transformative theory. However, the limitations in study were related to the individualized setting, the limited generalizability that encouraged further research on its findings.

Another study that indicated positive outcomes that employed transformative lens in investigating adult learning was Peters, Watkins and Bennett (2014). Peters et al. conducted a qualitative study framed by transformative learning theory that investigated professional development designed to support middle and high school mathematics teachers' reasoning and learning in statistics (2014). In the summer professional development program teachers experienced powerful pedagogical strategies for teaching statistics, opportunities to engage in

rational discourse with other teachers and to reflect critically on their activity and practices to enhance their skills and knowledge. Peters et al. (2014) used multiple data sources in this study including semi-structured interviews, recordings of professional development sessions, written work, and classroom observations. By rigorous data analysis such as constant comparative, Peters et al. obtained descriptions of teachers' reasoning in relation to the constructs. Their results suggested that dilemma, rational discourse, and critical reflection assisted teachers in deepening their understandings on areas of the content. They revealed that reflection, through justification and consolidation of thoughts, brought further enlightenment and sustainability to thoughts. Overall, this study contributed to teacher education by identifying circumstances conducive to deepening statistical understandings and supporting reasoning in increasingly sophisticated ways but raises questions about what support might affect broader teacher populations (Peter et al.).

More recent Steyn (2017) studied the role of transformative learning in the process of knowledge acquisition and skills development in the mathematics department at the school using a qualitative case study approach. The study formed part of an on-going project on the professional development of teachers at a purposefully selected school because of the school's emphasis on teacher collaboration. Steyn relied on questionnaire, focus group interview and individual interviews for data collection (2017). While maintaining the transformative framework several qualitative analyses of data were done to uncover that transformative learning

in teams is well worth adopting in schools as the findings were positive for both practitioners and scholars. The study revealed how the nature of transformative learning, the sharing of professional practice, time for dialogue, structured teams and professional relationships contributed to transformative learning. Their recommendation is for future research into transformative theory development in different context.

In a qualitative inquiry based on criticality and interpretivism paradigms, Bonghanoy, Sagpang, Alejan and Rellon (2019) investigated university researchers and teachers attempt to redesign professional development training for mathematics teachers in the Philippines. After three to six months of immersion in the field mentoring and collecting data including daily data logs, employing Key Informant Interviews (KII), classroom observations and student interviews the researchers found multiple gains from using transformative learning. For instance, Bonghanoy et al. reported that students' interest and retention were addressed, and student participation was maximized. They mentioned that teachers' reflections played an integral part in transformative learning. The conclusions stated that transformative teacher development accounted for systematic growth of teachers and students and enabled them both to become critical agents.

Transformative Learning Theory and Professional Development

The new approach to professional development as viewed by Guskey (2000), is to improve the professional knowledge, skills and attitudes of educators through planned processes and activities to effect student learning. Also, new knowledge in teaching and learning demands building the knowledge base of educators (Fullan, 2002) and the development of experts in education (Guskey,2000). Although professional development has received wide recognition, the mechanism related to how teachers acquire knowledge and skills for transfer and change in their belief, attitudes and practice to improve the learning of all students is not explained by a unified theory. Considering the systematic effort to bring about change that is lasting it becomes necessary to apply critical reflection as a core feature of transformative learning theory that has far reaching implications for facilitating adult learning and teacher change according to Taylor (2009). Grounding professional development in a transformative theoretical framework will reveal the process of development and further devise plans that contribute to the effectiveness of professional development programs.

Transformative theory can provide the lens to uncover how the Primary Specialist Teacher Model Pilot Summer Training Workshops held in Jamaica, mathematics component was implemented cognizant that context shapes adult learning. There are several reasons for using transformative learning theory. Foremost, the mathematics curriculum is rooted in constructivist

learning theory while the mathematics professional development underpins a theory of change that stands in coordination with Mezirow's (1978, 1991, 1994,1996, 1997, 2000, 2009) transformation learning theory to identify the processes of adult learning for examining teacher learning and change. In fact, any discussion about learning that inspires change should consider transformative learning theory. The most significant changes in a teacher's practices, attitudes, beliefs, and perceptions are functions of transformations of meaning perspectives and meaning schemes (Mezirow, 2009). Although theory is used extensively in the field of research transformative learning theory is most appropriate for this context and the topic of this study. The primary mathematics specialist teacher profession development then should foster and nurture factors of transformative learning theory that facilitate integrating adult teaching practices such as a disorienting dilemma (trigger event), prior experiences, reflection, motivation and engagement, and relationships that can lead to increased engagement, changes in teachers' knowledge, beliefs, and classroom practices (Christie et al.).

Next, adult education defines more mature level of cognitive functioning. Ideally transformative learning theory emphasizes a learning process that fosters autonomous thinkers (Mezirow, 1978, 1990, 1991, 1994,1996, 1997, 2000, 2009). As aforementioned, adult learners' autonomous development is the primacy of the theory and within this realm professional development is positioned to develop lifelong learners and to enhance or bring about profound change from traditional views. Adult educators must demonstrate critical reflection among their

students (King, 2004) and use facilitation and modeling approach, for example embracing humanistic and constructivist techniques in the discourse (King & Heuer, 2009). Facilitating the learners' critical reflection (Beavers, 2009; Christie et al.; King, 2004; Peters et al.) of the professional development experience can stem the acquisition of new attitudes or beliefs, or simply modification of older ones (Mezirow, 1997).

Another reason is that the conceptual framework in this study will include Joyce and Shower's (2002) model of professional development that can be aligned with critical reflection (Taylor, 2009) to understand the change. The model consists of four critical elements (knowledge of theory, demonstration, practice and peer coaching) for accomplishing transfer of knowledge based (Joyce and Shower, 2002). Furthermore, transformative learning is a process of "perspective transformation" that has three dimensions: psychological (changes in understanding of the self), convictional (revision of belief systems), and behavioral (changes in lifestyle)" (Mezirow, 1978, p. 101) for gaining insights. The model for professional development offers the process to foster the changes that are expected and are tuned to critical reflective practice, an element of skillful teaching (Brookfield, 2015). The notion of a disorienting dilemma is often a reason for learning to occur. For instance, teachers are faced with the challenge of facilitating mathematics learning with recognition of innovations based on knowledge of content and pedagogy (Shulman, 1986). The role of prior experience acts as a springboard for the facilitator tap into learners' prior experiences for building on existing knowledge, beliefs, and practices. In

addition, the learners' wealth of experiences must relate to new experience by way of integrating their everyday live for sense making for them to value the experience (Meriam et al.). The interdependence of the core elements of transformative learning theory (Taylor, 2009) will contribute to the manifestation of critical thinking relative to all areas of Joyce and Shower's (2002) model of professional development. Thus, teachers may critically reflect on areas of the training to determine how they respond to the training such as becoming motivated to acquire new knowledge and transfer it into their practice.

Finally, learners' diversity, experience and needs must be considered (Lawler, 2003). The climate, the methods, and learners' input are factors that can impact adult learning (Lawler, 2003).Transformative theory posits that when trusting relationships are established, learners will be more likely to respond deeply to inquiry and self and critical reflections will be fostered and nurtured (King, 2004; King & Heuer, 2009; Lawler 2003; Peters et al.). Similarly, professional development that will be most beneficial to adults must focus on the learner-centered climate, encourage active participation, build on experience, employ collaborative inquiry, learn for action and empower participation (Gregson & Sturko, 2007; King, 2004; King & Heuer, 2009; Lawler 2003). Merriam and Bierema (2014) emphasized creating space (safe, supportive and open) can encourage deep understanding and appreciation of personal and socio-cultural influences.

Although coercive and power are not supported by transformative learning theory (Mezirow, 1997; Taylor, 2009), Ettling (2012) argued that they hold a place in the theory. For instance, in professional development the teachers can be led to the edge of their comfort zone in order to confront and disrupt personal assumptions (Ettling, 2012). The practice of critical reflection interrelates with professional development as the same principles that foster critical reflection are the characteristics of an effective professional development. Hence, it is possible to use critical reflection to understand how and why the mathematics professional development worked.

Mathematics Curriculum

A curriculum is the series of experience that provide exposure for learners to develop attitudes, understanding and skills that are essential in life (Morris, 1955). It is the policy that is defined by the curriculum that directs the program of activities the teacher uses to shape knowledge and to enhance skills. A mathematics curriculum must be clear, connected, coherent, focused and articulated alluding to the features of Singapore's curriculum which accomplishes continuous success in mathematics (Checkley, 2006).

A superior mathematics curriculum is one that provides students with deep understanding as they move through the education system, such curriculum is described as: coherent, focused, and articulated (Beesley & Apthorp, 2010; Checkley, 2006;). Whereas coherent mathematics curriculum has consistent connections with new knowledge and skills, curriculum articulation

refers to how the parts of the curriculum relate (Beesley & Apthorp, 2010). These critical features of a curriculum aim at influencing rigor and deep understanding to combat the disjointed contents of textbooks and other instructional materials (Beesley & Apthorp, 2010). This is achieved when the issues of design, content, connections and meaning are addressed (Checkley, 2006). It is notable that curriculum coherence is a fundamental component of curriculum vision, wherein, teachers and students make mathematical connection across lessons (Cirillo, Drake, Herbel-Eisenmann, & Hirsch, 2009).

Fundamentally, the connections between the aim and the daily life must be visible and students must make sense of the learning experiences, therefore, setting goals as the benchmarks to determine accomplishment and to decide on applicable teaching instructions enable schools to meet the standards (Checkley, 2006). In addition, Beesley and Apthorp (2010) embraced the importance of learning mathematics and the standards with expectations for students to learn and value mathematics, encouraging procedural skills, as teachers balance inquiry-based learning and direct instructions (Beesley & Apthorp, 2010).

The History of Mathematics Program

The progress in curriculum thinking was strongly influenced by forerunners, Edward Thorndike and John Dewey, who impacted the educational landscape at the start of the twentieth century in setting the intellectual tone and direction for inquiry into education, more so, the curriculum field (Eisner, 1985). Thorndike's assumptions were that schooling is the development

of a science of educational practice, related to agriculture, engineering or medicine (Eisner, 1985) while Dewey envisioned teachers playing the role of a guide, rather than being the center of the learning process (Klein, 2002). In line with these thinkers, Battista (1999) argued that if the United States is to develop future professionals of relevance in a competitive global world it is imperative to embrace research-based initiatives to enhance mathematical learning since mathematics is a fundamental discipline for future careers.

Mathematic education has experienced considerable revisions over the last century. However, by the 1980s, the extensive development of computer technology coupled with scientific research on mathematics learning has shifted the educational landscape (Battista, 1999). The historical account of mathematics education in the Unites States highlights the dominance of progressivists' mandate for approximately half a century, challenged by New Math before resurfacing in 1970 (Klein, 2002). However, with the old programs of the 1920s and the development in education the momentum was short. In response to the failure of the traditional methods of teaching mathematics the National Council of Teachers of Mathematics (NCTM) in 1989 presented the Curriculum and Evaluation Standards for School Mathematics, redefining mathematics learning to constructivist theory (Klein, 2002). This approach allows students to construct their mathematical ideas to make sense of the situations in contrast to over 40 years practice of the behaviorist learning theory of imitating, rote learning, and memorization (Battista,

1999). Researchers have criticized such teaching practices that characterize classrooms with large dosages of memory learning (Cannella and Reiff, 1994).

Supporting the constructivist theory articulated by the NTCM, the National Scientific Foundation (NSF) funded several mathematics programs for students at different educational levels from kindergarten to high school (Klein, 2002). The NSF programs included: *Everyday Mathematics, Investigations in Number, Data and Space, Math Blazers for* K-5, C*onnected Mathematics Project (CMP), Mathematics in Context (MiC), MathSpace, Middle Grades Math Thematics, Middle School Mathematics Through Applications Project (MMAP)(6-8), Contemporary mathematics in Context (CORE Plus), Interactive Mathematics Program (IMP), Mathematics Connections, Mathematics: Modeling Our World (ARISE) and SIMMS Integrated Mathematics (9-12)* (Klein, 2002).

Today there are numerous mathematics programs available for schools that are aligned to CCSS and Singapore's math curriculum. Singapore's math curriculum has gained increased attention worldwide. Over 40 countries including the U.S. and the United Kingdom have adapted Singapore Math, for its position as the top in international benchmarks such as TIMSS and PIRLS (What Is Singapore Maths? n.d.).

The National Standard Curriculum for Mathematics in Jamaica

Jamaica implemented the NSC in schools at grades 1-9 in September 2016. It was developed in collaboration with the United Nation's Children Fund (UNICEF) and other stakeholders. The NSC emanated from recommendations in the 2004 Education Task Force Report and reviews of the former curricular (Ministry Education, Youth and Information, 2016). It has replaced the Revised Primary Curriculum and National Grades7-9 Curriculum that have shaped schools since 1999. The former curricular were criticized as being too content heavy and focused on retention of factual knowledge rather than transferable skills and competencies among other deficiencies (Ministry of Education, Youth and Information, 2016).

The new approach to teaching and learning that the NSC features places direct emphasis on project-based and problem-solving learning, with Science, Technology, Engineering and Mathematics/Science, Technology, Engineering, Arts and Mathematics (STEM/STEAM) integrated at all levels. The curriculum is based on a set of subject areas that forms the content, with problems presented to be explored through methods that are student centered (Morgan, 2016). For effectiveness in using the methods teachers need to understand constructivist learning which is "a fundamental theory that has influenced the values and principles upon which the curriculum rests" (Morgan, 2016, p. 29). The main values that underly the NSC include the Jamaican culture and heritage, tolerance and respect, sustainable development, inclusivity, and

social justice and democracy. The NSC aims to enhance the quality of education and improve academic performance, attitude and behavior of students, in order to positively shape the social and economic fabric of Jamaica (Ministry of Education, Youth and Information, 2018).

In line with the constructivist learning theory, the NSC emphasizes some core principles to ensure quality education for all learners such as development of competencies, attention to present day realities and the future, learning progression, learning styles, divergent thinking and outcomes, the place of culture in learning and inclusive, empowering and thought-provoking context (Morgan, 2016). Brooks and Brooks' (1999) concurred with Gagnon and Collay (2001) in describing constructivist learning theory as one that engages students in formal learning as they would participate in informal learning in their life experiences out of school. Hence, the constructivist learning theory embraces four principles: learning is dependent on existing understanding, learners construct their own meaning, social interaction plays a key role, and authentic learning tasks are critical for meaningful learning. In mathematics, the constructivist view of students' learning is a process of constructing meanings and making connections with the activities and the representations (Krahenbuhl, 2016).

The NSC adopted eight mathematics teaching practices for instructional strategies and approaches necessary to promote deep learning of mathematics from the NCTM, 2014 (Ministry of Education, Youth and Information, 2017) that embrace the constructivist theory. The teaching

practices are: (1) establish mathematics goals to focus learning, (2) implement tasks that promote reasoning and problem solving, (3) use and connect mathematical representations, (4) facilitate meaningful mathematical discourse, (5) pose purposeful questions, (6) build procedural fluency from conceptual understanding, (7) support productive struggle in learning mathematics, and (8) elicit and use evidence of student thinking (Ministry of Education, Youth and Information, 2017, p. 5). These practices are aligned to the National Numeracy Policy of the Ministry of Education, Youth and Information that indicated that mathematics teaching will: (a) 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 and (b) encourage mental processes, including the use of mental imagery, as a tool for exploring mathematical situations (Ministry of Education, Youth and Information, 2017, p. 3).

The NSC for mathematics at grades 4-6 is also aligned to the National Comprehensive Numeracy Program which suggested that by learners exit primary school they should have attained success in understanding and using foundation mathematics concepts (Ministry of Education, Youth and Information, 2017). The program suggested that these graduates should have experienced the three critical prongs of mathematical fluency: conceptual understanding, computational, procedural fluency and problem-solving skills or strategic competence (Ministry of Education, Youth and Information, 2017). The writing process for the units for Grades 4-6 mathematics includes the afore mentioned as well as the process strands: problem-solving,

reasoning and proof, communication, connections, and representation. From the five process strands a distinct standard is developed for each of the five content strands: number, measurement, geometry, algebra, statistics and probability (Ministry of Education, Youth and Information, 2017).

The goals of the learner at grades4-6 in the mathematics component of the NSC are also in tandem with the constructivist principles. The goals are described as developing the necessary competencies to function in society, conceptualizing spatial properties, gathering and representing data in different ways, manipulating mathematical ideas and tools, and applying mathematical knowledge to real life situations (Ministry of Education, Youth and Information, 2017). These goals embrace the 21st century learning that is conceptualized as the four Cs: communication, collaboration, critical thinking, and creativity (Ministry of Education, Youth and Information, 2017).

The 21st century model for education will better prepare students for the demands of citizenship, college, and careers in this millennium (National Education Association, 2019) Critical thinking in the 21st century is discovering facts and engaging with the environment. Communication is the practice of conveying ideas quickly and clearly. Practicing collaboration helps students understand how to address a problem, pitch solutions, and decide the best course of action (Applied Educational System, n.d.). Creativity helps students to view a problem from

multiple perspectives. These skills are discussed as essentials for the 21st century mathematics classrooms in Jamaica placing great emphasis on the role technology plays in promoting the development of these skills (Ministry of Education, Youth and Information, 2017).

The depth of knowledge (DOK) is also focused in the NSC. The NSC presents the DOK principles to assist teachers in their mathematics assessment. Prior knowledge is fundamental to the teaching of mathematics (Ministry of Education, Youth and Information, 2017) which Jerome Bruner conceived as the foundation for new concepts in constructivist learning theory (Narayan et al., 2013). Another fundamental area of the NSC mathematics curriculum is incorporating the STEM approach and 5E model in lesson planning and mathematical activities.

The 5E instructional model, referred to as “Five Es” is based on constructivism learning theory and was developed by the Biological Science Curriculum Study (BSCS), a team led by principal investigator Roger Bybee (An Educator's Guide to the "Four Cs", n.d.). Tezer and Cumhur (2017) in their researcher, accentuated that the model works effectively in teaching mathematics to grade 8 students. The 5E instructional model aim is to aid students in developing their understanding from experiences and new ideas based on the five stages for a sequence of teaching and learning activities: engage, explore, explain, extend/elaborate and evaluate (An Educator's Guide to the "Four Cs", n.d.).

In the model, the purpose of engage is to intrigue students and to get them involve while assessing their prior knowledge. Explore aims at getting students involve and giving them the

chance to build their own understanding while explain in that context suggests that students are provided an opportunity to communicate the knowledge gained and to determine what it means (An Educator's Guide to the "Four Cs", n.d.). To extend/elaborate students continue to use their knowledge to explore its implications leading into the final stage, to evaluate, when teachers and students determine how much learning and understanding has taken place (An Educator's Guide to the "Four Cs", n.d.).

Program Evaluation

The field of evaluation is a distinct profession and a fundamental discipline that emerged in the late 1960s. Evaluation theory has evolved over the years with valuable contributions of experts in the field who built on and advanced each other's work (Guskey, 2000). Compared to the few earliest professional societies of evaluation in the 1960s and 1970s the field has been widely developed with over 50 national and regional evaluation organizations worldwide at present (Stufflebeam & Coryn, 2014). In 1974, the field herald professional journals publications that focused on the scholarship and practice in evaluation. *Evaluation and Program Planning* was one of the earliest types. Although there is a proliferation of scholarly evaluation journals, these publications are not the only repository for all related work as some scholars and practitioners disseminate their work in discipline-specific journals such as health and medicine, education, psychology or subject-specific areas like statistics. The Joint Committee on Standards for Educational Evaluation was one of the recognized standards developed for evaluating

programs, personnel, and students. According to Guskey (2000) this committee provided a guide for evaluation practices in education after many years inconvenience of adequate and appropriate standards.

Evaluation is interrelated to all other professions as rigorous evaluation carried out regularly in these professions enhances growth in terms of assessing and improving quality while meeting the requirements for accountability. On the other hand, evaluation relies on other professions like sociology, political science and education for methods, concepts and criteria (Stufflebeam & Coryn, 2014).

Fitzpatrick, Sanders, and Worthen (2010) summarized a program evaluation as a process that uses inquiry and judgment methods to (a) determine standards, (b) collect relevant information, and (c) determine value, effectiveness, or relevance of a program. Simply put, program evaluation is defined as the act or process of ascertaining the merit, worth, or significance of something of the product (Stufflebeam & Coryn, 2014). The merit or worth of the evaluation denotes its value based on the intrinsic and extrinsic values of the program in terms of quality or excellence and the culture relating to needs, costs and circumstances. Need is defined as something that is vital or useful for filling a defensible purpose, without addressing this need satisfactory function cannot take place (Stufflebeam & Coryn, 2014). Needs is characterized as treatment or outcome. For instance, the need for an appropriate curriculum and competent

teachers in a specific discipline is the treatment need for schools while students need to develop competencies in that particular discipline is the outcome need.

Evaluation must be a systematic undertaking to ensure it is thorough in collecting high quality information and clarifying and providing a defensible rationale for the value perspectives used for interpretations of findings and judgements made as well as in reporting findings to intended audiences (Stufflebeam & Coryn, 2014). Furthermore, systematic evaluation incorporates relevance, control for biasness, and consistency with professional standards.

Case study is an appropriate approach in program evaluation (Stufflebeam & Coryn, 2014). The main feature of a case study is an in-depth, non-interventionist examination of the case that results in a descriptive and judgmental report with the perceptions held by different stakeholders and experts, and summary conclusions. Investigators closely examine the context of the program that is producing the outcomes which includes: participants' needs, input, operations, intended and unintended effects accounting the challenges involved. The sampling technique for a case study approach evaluation requires that the evaluator observes the nonprobability sampling by assessing the field of potentially useful respondents' representative of the of the overall body of program participants. An evaluator can choose a collective case, an intrinsic or an instrumental case study. A collective case study examines a number of cases together to inquire into the phenomenon for the individual case will increase knowledge about a

larger group of cases to provide a unique result. This approach facilitates triangulation of multiple perspectives using a range of methods and sources of information (Stufffebeam & Coryn, 2014).

Program Theory

A program theory explains how an intervention (a project, a program, a policy, or a strategy) is understood to contribute to a chain of results that produce the intended or actual impacts (using logic models and theories of change better in evaluation, n.d.). Theory informs practice as a result a program theory forms a general framework in coherence with a set of conceptual, hypothetical, pragmatic, and ethical principles to guide the study and practice of program evaluation (Stufflebeam & Coryn). Program theory is useful in bringing out existing evidence about a program and clarifying where there is agreement and disagreement about how the program is understood to work, and where gaps exist in the evidence (Treasury Board of Canada Secretariat, 2012).

A predictive assumption that implies the processes for the desired changes defines the theory of change (Conolly & Seymour, 2015). Hence, the theory of change articulates how a project is intended to achieve its outcomes. To employ the theory of change requires a planned approach that elicits steps to determine the extent of effectiveness based on the long-term goal, ultimate-goal, output, and outcomes (Msila & Setlhako, 2013). In tandem with the theory of change, Kellogg (2004) illuminated that a logic model is a systematic visual way of clarifying

the relationships among the resources in the program, actions to be taken, and the expected changes or outcomes. Figure 1 shows a generic Logic Model.

Figure 1. Generic Logic Model.

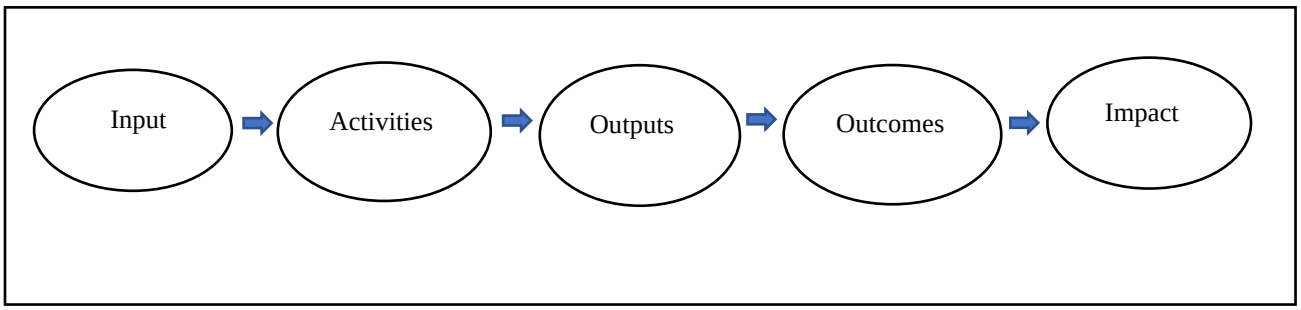

Figure1. Generic Logic Model. Adapted from "*Logic Model Development Guide*" by W.K. Kellogg Foundation, 2004, p. 1. Copyright 2004 by W.K. Kellogg Foundation.

The generic logic model illustrated in Figure 1 informs the theory of how the intervention works. Laing (2015) elaborated that developing a casual modal that links the inputs of the program to the chain of outcomes, serves as a guide for an evaluation. The theory of change is identifiable with as a clear road map for change as it guides the program implementation. However, when input-outcome methods are used without a casual chain that explains the principle it is termed as "black box" thinking (Msila & Setlhako, 2013; Laing, 2015). An explanation of casual mechanism is necessary in determining certain inquiries, for instance, how do we know it works? Who does it work for? And, in what circumstances? (Msila & Setlhako, 2013; Laing, 2015).

Professional Development

With demands for educational reform and school improvement, as well as the push for standardized testing coupled with the pressure of accountability, professional development seems to be the route for teachers to keep up (Guskey, 2000; Garet, Birman, Yoon, Porter, and Desimone, 2001). Teachers need to be effective in their practice and committed for student achievement as Garet et al., (2001) asserted, they require continual deepening of knowledge and skills as professionals. Therefore, effective professional development activities must be ongoing and sustained throughout a teacher's career (Borko, 2004). However, in response to issues of teacher quality and student learning, researchers (Joyce, Showers, and Bennet, 1987) on professional development accentuated three developments that hold promise: the expansion of programs that can increase student learning, the guidelines provided by research on staff development and curriculum implementation to aid in designing and implementing programs gear to increase teachers' repertoire of teaching skills, and innovations from research indicate that sustained change in instructional practice largely depends on a shared understanding about the nature of the innovation and what it can accomplish.

Correspondingly Guskey (2000) defined professional development as "those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students" (p. 16). Learning Forward (2011),

emphasized that professional development is geared at improving both teachers' and principals' effectiveness in raising student achievement. The scope of this meaning includes developing both teachers and principals' effectiveness conforming to Joyce and Calhoun's (2010) idea who maintained that they are the central clients of professional development. Therefore, professional development constitutes a priority on developing academic standards, providing opportunities for student as well as teacher learning needs, monitoring of resources, embedded ongoing implementation, and assessments evaluating professional learning activities (Desimone, 2011). Simply put, "professional development is about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth" (Avalos, 2011, p. 1). Hence, it is meaningful activities that provide educators with the knowledge and skills necessary to produce successful students.

Fundamentally, Hirsh (2009) postulated that professional development must bolster a teacher's efforts to analyze data, establish outcome-oriented goals, utilize research-based strategies in daily instructions and provide coaching for successful implementation of learned techniques and improved instructional practice. For this reason, it can be characterized as sustained, intensive, collaborative, data driven, and classroom focused (Learning Forward, 2017). Additionally, three defining characteristics of professional development process are that it is intentional, on-going and systematic (Guskey, 2000). This explains its deliberate arrangement

of organizational processes and structures in an attempt to facilitate school wide competence in teachers and administrators (Joyce & Calhoun, 2010).

Teachers experience a vast range of activities and interactions that can increase their knowledge and skills, improve their teaching practice, and contribute to their personal, social, and emotional growth (Cohen, McLaughlin, & Talbert 1993). These experiences range from formal, structured seminars, workshops, local and national conferences, college courses, special institutes, in-service days to everyday activities, and informal hallway discussions with other teachers (Desimone, 2011). The major models are training, observation, involvement in development, study group, inquiry/action research, individually guided activities and mentoring of which training is the most common and is often synonymous with professional development (Guskey, 2000).

Although there is general acceptance of professional development as essential to education reform (Guskey, 2002) many studies contest its effectiveness and researchers have developed considerable models to design and to evaluate its effectiveness. An evaluation of a professional development serves to improve the quality of current professional development efforts, and to determine its effects (National Staff Development Council, 2001). Thus, evaluation design is determined by the purpose for the evaluation (to improve something or to judge its worth) and by the audience for the evaluation's findings (Guskey, 2000; National Staff

Development Council, 2001). Guskey (2000) established a framework to determine the effectiveness of a program or activity. His aim was to provide meaningful information for decisions about professional development processes and effects. Hence, to evaluate whether a program is achieving its purposes Guskey suggested that collection and analysis of data on the five levels in his framework be applied. Guskey's (2000) five critical levels of effective professional development evaluation includes: participants' reactions, participants' learning, organization support and change, participants' use of new knowledge and skills and student learning outcomes. Each level builds on the prior level and becomes more complex at succeeding in gathering information for the evaluation process. These five levels represent an adaptation of an evaluation model developed by Kirkpatrick (1959) for judging the value of supervisory training programs in business and industry. Kirkpatrick's model limitation in education has been due to its inadequate explanatory power. It is helpful in addressing a broad range of "what" questions however, it is lacking in explaining "why". Ideally, to better understand professional development so it can be strengthened it is important to know why it does or does not work and how it can be improved.

Level 1 of Guskey's (2000) framework forms the most common type of evaluation and the easiest to collect and analyze data. The focus at this level is on participants' reactions to the professional development experience using questions that relate to how participants found the experience in terms of purpose, meaning and accommodation. Level 2 focuses on measuring the

knowledge and skills that participants gained relative to the goals of the program. Hence, measures must show attainment of specific goals with indicators of successful learning that were stated in the program. Level 3 concentrates on the organization and how change is supported, centrally the organization characteristics and attributes are areas to focus the questions. Lack of organizational support can stifle the efforts of implementation activities when all activities are done right based on the prior levels. This level emphasizes that without organizational support and change the gains made at Levels 1 and 2 would have aborted and impeded the profound efforts to encourage student learning. For this reason, school wide improvement initiatives require the involvement and commitment of everyone (Darling-Hammond and McLaugh, 1995; Elmore, 2014; Fullan, 2015; Guskey, 2000; National Staff Development Council, 2001; Joyce & Calhoun, 2010: Joyce & Showers, 2003). To build the capacity for change the development of school norms which support the continuous improvement of teaching is important.

Level 4 is directed to the use of new knowledge. Guskey (2000) stipulated that specifying clear indicators of both the degree and the quality of implementation can gather essential information on this level. Unlike Levels 1 and 2, adequate time is needed for adaption of new practices hence, information on Level 4 cannot be gathered at the end of the professional development session. Gathering information from questionnaires or interviews from participants and their supervisors and direct observations were recommended. The analyzed information is useful to refine programs and enhance consistency in implementation (Guskey, 2000).

Guskey (2000) referred to Level 5 as student learning outcomes which is the most crucial stage as it is concerned with how the professional development activity affected students in relation to the goals of the session. Although measures of student learning outcomes are generally student performance on achievement such as grades, scores, standardized tests Guskey (2000) suggested measuring affective and psychomotor outcomes as well. Three useful caveats of the Guskey's Five Level framework state: each level provides vital information, success at one level is not automatic at the next level and the use of backward planning for professional. The backward planning process begins with the student learning outcomes (Level 5) and follows the sequence up to Level 1 where the decisions made at each level intensely affect the next (Guskey, 2000).

To improve the quality of evaluation the Joint Committee on Standards for Educational Evaluation published a list of 30 program standards focusing on utility, feasibility, propriety, and accuracy (2011). The utility standards are the attributes that determine whether the evaluation will provide the information needed by the desired audience. Feasibility standards establish the criteria to ensure the evaluation is realistic. Propriety standards establish guidelines to ensure the evaluation is legal, ethical, and protects the welfare of participants in the evaluation. Finally, accuracy standards are the requirements to utilize technically accurate information in the evaluation process. Parallel to this, Guskey's (2000) indicated that these evaluations are more of a summative evaluation for the purpose of decision making by neglecting other types of

evaluations (planning and formative). Further, he argued that they do not conform to the definition of evaluation as a "systematic investigation of merit and worth" (Guskey, 2000, p. 41). Their limitations as argued by Guskey (2000) denote three factors. First, the focus is on activities and funding not issues related to value, effectiveness and results. Second, these evaluations are comparable to Guskey's (2000) Level 1 hence, they are too shallow for evaluations. Last, the evaluations are brief, of such, they are mere documentation (Guskey, 2000).

Desimone (2009) suggested that researchers apply research knowledge to improve conceptualization, measures, and methodology on the effects of teachers' professional development on teachers and students. Along this line, Desimone (2009) articulated a theory of how professional development works to influence teacher knowledge and beliefs, classroom practice, and student outcomes (Guskey, 2000). Desimone emphasized that a conceptual framework that defines important features of teacher learning experiences has the potential to move the field forward in terms of building a consistent knowledge base (2009, 2011).

Several recent studies have begun to examine the importance of specific characteristics of professional development (Desimone, 2009, 2011; Desimone, Porter, Garet, Yoon, Birman, 2002; Garet et al., 2001; Guskey and Yoon, 2009; Ingvarson, Meiers & Beavis , 2005) few studies have explicitly compared the effects of different characteristics of professional development. Thus, there is a clear need for a new systematic research on the effectiveness of

alternative strategies for professional development. An analysis of extant empirical research according to Desimone (2009, 2011) revealed a consensus of five main features of professional development to measure its effectiveness that have been associated with changes in knowledge, practice and student achievement. The core features include content focus, active learning, coherence, sustained duration and collective participation (Desimone, 2009; Desimone, 2011, Desimone & Garet 2015). Considerable evidence supporting the five features comes from cross-sectional studies (Desimone, Porter, Garet, Yoon, Birman, 2002; Garet et al., 2001; Guskey and Yoon, 2009; Ingvarson, Meiers & Beavis, 2005), and literature reviews of qualitative and quasi-experimental studies (Desimone, 2009; Desimone & Garet, 2015).

Desimone and Garet (2015) attempted to refine the core features of professional development (Desimone, 2009) based on an examination of recent rigorous research on professional development in the United States. They found mixed results from studies that used Desimone (2009) conceptual framework. But notable, they deduced that effectiveness of professional development rests on two theories: a theory of change and theory of instruction. However, they proposed five fundamental implications for effective professional development: (1) changing procedural classroom behavior is easier than improving content knowledge or inquiry-oriented instruction techniques; (2) teachers vary in response to the same professional development; (3) professional development is more successful when it is explicitly linked to classroom lessons; (4) professional development research and implementation must allow for

urban contexts; and (5) leadership plays a key role in supporting and encouraging teachers to implement in their classroom the ideas and strategies they learned in the professional development.

In a meta-analysis conducted by Guskey and Yoon (2009), 1,300 studies were reviewed that potentially addressed the effect of teacher professional development on student learning in mathematics, language arts, science and reading but only nine studies met the 'What Works Clearing House' standards. The analysis noted consistency on the content that led to improvement in student learning in the nine studies. They focused on specific subject-related or pedagogic and by implementing that content those instructional practices justified how student learning took place. On the same vein, Darling-Hammond and Richardson (2009) contended that true professional learning that enhances teachers' professional practice as well as student learning must consist of content that is active and sustainable and considers student learning in the context of school improvement goals. Effective professional development involves teachers being dually learners and teachers where the process allows them to struggle with the uncertainties that accompany each role (Darling-Hammond and McLaughlin, 1995). These activities must respond to participants' different learning styles and strengths and include opportunities for them to do various actions in relation to the content (National Staff Development Council, 2001).

In Showers, Joyce and Bennett's (1987) meta-analysis of nearly 200 research studies they reported that the role of the trainer and information on where and when the training was held were not as critical as the training design. Another profound finding was that almost all teachers applied knowledge to classroom context when the training comprised of four parts: (1) knowledge of theory, (2) modelling of skill, (3) practice of skill, and (4) peer coaching (Bush, 1984). Joyce and Showers (2002) echoed that those were the key components of training. In thinking that training designs have come to strike a distinction between awareness-raising as a training objective, and behavior change, Joyce and Showers (2002) developed and refined a vision for training to expand teacher's professional repertoire with new knowledge. Their position is that training must aid persons to become effective learners so that they can acquire new knowledge and skills and transfer the skills into practice. The suggestion is to identify the outcomes that are intended in the training and match them with the training components. Fundamentally, teachers' effectiveness as learners depends on attitudes and skills such as persistence, acknowledgement of transfer problem, teaching new behaviors to student, understanding the importance of the underlying theory, proactive and productive use of peers and flexibility (Joyce and Shower, 2002).

According to Joyce and Showers (2002) knowledge and theory formed the first component in the design, where emphasis is on the rationale for the new strategy. Demonstration refers to the opportunity to demonstrate the strategy in similar context to the workplace. The

third component is the practice of the skill. Attaining a comfortable position of medium complexity teaching model deserves 8-10 weeks with an estimation of 25 trials. Finally, peer coaching is the collaborative work of teachers to plan and develop teaching activities to implement the training effectively.

Garet et al. (2001) examined the relationship between features of professional development and self-reported change in teachers' knowledge and skills and classroom teaching practices. They examined three core features of professional development activities: (a) the degree to which the activity has a content focus (b) the extent to which the activity offers opportunities for active learning, and (c) the degree to which the activity promotes coherence in teachers' professional development. The teacher outcomes measured self-reported increases in knowledge and skills in several different areas (e.g., use of technology, instructional methods, approaches to assessment), and changes in classroom practice. The findings from this study provide empirical confirmation of the assumptions in the literature on best practices in professional development. The results also showed that sustained and intensive professional development that focuses on content, active learning and coherence were more likely to produce positive outcomes such as enhanced knowledge and skills. The study also supported the collective participation feature that the authors have found to be interrelated with coherence and active learning opportunities, which in turn are related to improvements in teacher knowledge and skill and changes in classroom practice. Based on the limitation in the study design

researchers suggested a need for longitudinal research focusing on the relationships among professional development, teacher learning, teacher change, and ultimately, student learning.

In a more recent evaluation of a professional development that was intended to improve teachers' mathematical knowledge for teaching and instructional quality conducted by Jacob, Hill and Corey (2017) the results were inconsistent. This randomized study was conducted in one midsize school district where 18 elementary schools and 105 teachers participated. Teachers actively engaged with the content of the professional development through summer workshops and in-year follow-up days, solving problems, discussing instructional approaches, and at times interviewing students and teaching demonstration lessons. Data collection consisted of observations of Math Solutions sessions by study staff, teacher surveys, video-recorded observations of teaching practice, and student assessments. Additionally, the district supplied demographic and test data for students participating in the study. Analyses were conducted to address each of the research questions. They also conducted two exploratory analyses to understand whether the treatment impacted subgroups of teachers and classrooms differently.

Although the program met almost all the criteria articulated in Desimone's (2009) description of effective professional development program features the findings revealed very limited evidence that the professional development may have had a small positive impact on teachers' mathematical knowledge for teaching. This finding was positive and statistically

significant only for one measure in one year of the three-year evaluation process. No changes in teacher measured instructional practices or in the achievement of their students were found. Careful examination into the theory of change for the program provided insight to possible reasons for the disappointing results. For the second and third year there was a drastic break down in leadership which negatively impacted the scheduling of in-service trainings as well as teacher attendance at training and caused the disconnect of priorities between the school and the district. Another possible explanation for the findings was that despite following the design of the program in terms of delivering the content, it did not lead to changes in instructional practice. The authors concluded that a professional development of that nature required more to make explicit link between knowledge and practice. Hence, coaching was a missing component of the program that they believed could have facilitated more positive outcome. Other findings mentioned that the program might not have been appropriate for meeting the teachers' need in the district. The conclusion was that substantial change occurs when teachers have the mind-set, the materials and ongoing support to implement what they have learned.

The value of professional development in implementing mathematics curriculum was supported by McGee, Wang and Drew's (2013) research that investigated elementary school teachers' perceptions of a yearlong mathematics professional development program. McGee et al. applied Guskey's framework for evaluating professional development to examine teachers' use of standard-based curricula. The authors employed a case study design to collect data to

answer the three research questions. Participants were 22 teachers from two elementary schools who were in the Mathematics Science Partnership (MSP) grant program by an application process, thus, 11 came from each school. Pre and post observations, interviews, classroom observations and focus group interviews along with the secondary source data from documents provided data for the study. In addition, the time spent in the field collecting data also added to the credibility of the study.

For data analysis the authors noted that they employed an interpretivist's approach grounded in the belief that multiple realities exist, and that personal understanding is gathered from experience. Constant comparison and open coding were done, and once common themes and patterns were found a code book was developed to refine data. Categorical coding was done pertaining to research questions and further coding was done to refine the themes. From the data analysis the researchers made sense of the refined information by presenting five themes relating to teachers' experiences with the professional development. Each theme was discussed providing direct quotes from participates to emphasis what their thoughts on areas they were asked about. McGee et al. (2013) accentuated that professional development is the central component of mathematics reform that advocates for standards-based teaching practice. Based on Guskey's framework that was used to evaluate the one-year professional development program, teacher-participants commented that they learned new mathematics content and that they became more comfortable using and teaching the standard-based curriculum which led to them changing their

instructional practices. According to McGee et al. some benefits teachers achieved from the professional development for the program were that they became more confident, less dependent on reading from the teacher manual during teaching and increased knowledge and skills in their pedagogy on problem solving techniques. Additionally, McGee et al. asserted that as teachers became more comfortable, they modified the *Investigations* lessons in different ways. The conclusions underscored the need for teachers to recognize the worth of professional development content prior to changes in their pedagogy and how deeply their beliefs are reflected in their practice parallel to other research as well as responding to the first level in Guskey's framework of teachers' perceptions (McGee et al.). The findings showed that although some teachers were not fully supportive of *Investigations,* they acknowledged that they gained knowledge as a result of the professional development.

McGee et al. (2013) mentioned some implications for professional development and for future research. In order to support the knowledge and skills teachers gained from the professional development training future professional development must address in-class support for teachers, teachers' immediate concerns, and the standard-based curricular and appropriate teaching instructions that support the state-mandated standardized tests. Although professional development training was commonly used to enhance pedagogy, there was need for research in areas such as how teachers translate the knowledge into class practice, classroom support that

influences teacher practice and learning, and how student achievement was affected by teacher learning, practice, and support.

In Obara and Sloan's (2010) study that examined three teachers' experiences using Connected Mathematics Project (CMP) materials during the introduction of the new GPS in the sixth grade. It was revealed that the summer institute on the CMP materials was not enough but that it had its advantages such as embracing the use of cooperate learning groups. The authors found the challenges the teachers encountered. It was also discovered that teachers with the least years of experience were most enthusiastic about the reform. From the findings, Obara and Sloan (2010) concluded that to successfully implement curriculum change there must be adequate and ongoing training and support for teachers and teachers' involvement in decision making for effective professional development that build on instructional strategies and teachers' enthusiasm and sense of ownership for instructional change. In addition, they explicated that when teachers clearly understand the objectives and the format of a new program its implementation can be successful. A limitation in this study was the difficulty to tell how much the teachers have changed without data of former teaching practices. Further research was suggested to provide teachers with essential resources to deal with the ongoing changes in the mathematics classroom.

In accordance, teachers showed positive attitudes toward teaching the new curriculum in a quantitative study (Aly & Abdulhakeem, 2016) that assessed the training programs for

mathematics teachers at the elementary stage on developed Curricula and attitudes toward teaching at educational administration in the context of Saudi Arabia. The findings also indicated that female teachers had greater interest in the training activities. In addition, the experience of teachers was not significant, but teachers agreed on the need for professional development in developed curricula. By employing survey methodology two questionnaire instruments were developed for data collection using the scale of the attitudes that measure mathematics teachers' opinion of training programs and their attitudes toward teaching the developed curricula respectively. The population of the study was all the mathematics teachers at the elementary level at the educational administration in Najran in Saudi Arabia in 2013-2014, who were trained in new curricula and the sample size was 72 teachers of equal gender. The authors also classified the results into five levels for analysis. The results were aligned to the research questions and tabulated to show the domain, mean, standard deviation, t-test and significant differences appropriately. Aly and Abdulhakeem (2016) indicated that future research was needed in intermediate and secondary training programs for mathematics teachers as well as to identify mathematics teachers training needs at various stages.

In light of these findings, researchers have sought to identify specific conditions under which professional development programs might produce positive results. Although the findings substantiated the impact of professional development on teachers' learning the lack of rigorous evidence on teaching practices and student learning posed concerned for professional

development to address acquisition of and transfer of knowledge, sustained support and collaboration and ultimately student learning (Guskey, 2000).

Teacher Change

The change in teacher instructional practices underlies professional development since change in teaching is possible when teachers experienced consistent, high-quality professional development (Desimone, Porter, Garet, Yoon, & Birman, 2002). In accordance, Elmore (2014) believed that both the characteristics of the professional development and the organization it serves determine if the professional development improves instructional quality and academic performance (Elmore 2014). He claimed that the professional development should consistently demonstrate the pedagogy that is expected of teachers in the context of the classroom.

Garet et al. (2001) maintained that shifting to a more balanced approach to teaching requires greater concentration on understanding subject matter (Shulman, 1986). Teachers need to learn more about the subjects they teach, and how students learn these subjects. The continuous deepening of knowledge and skills is an integral part of any profession (Fullan, 2002; Guskey, 2000). Equally, teachers "need sustained, ongoing professional development... they must continue to learn new or additional mathematics content, study how students learn mathematics, analyze issues in teaching mathematics, and use new materials and technology" (NCTM, 2000, p. 370).

According to Elmore (2014) most learning occurs through experimentation and error, not through straight linear process. In this regard, the National Staff Development Council (2001) argued that adult learning requires engagement in three dimensions of change process. The activities must move learners beyond an understanding of surface features of an innovation to a more complete understanding of its purposes, critical attributes, meaning, and connection to other approaches (Mezirow 2000; National Staff Development Council, 2001). Adult learning must promote deep understanding hence teachers require many opportunities to practice new skills with feedback through active learning processes (Darling-Hammond & McLaugh, 1995; National Staff Development Council, 2001; Joyce and Showers, 2002). Secondly, the pressure for change may impose feelings that may negatively impact teachers' intention to use new models (National Staff Development Council, 2001). The final dimension of change is the life stage of individuals engaged in the change process. It is important to consider an individual's availability and interest in additional work responsibilities at different phases of life. Life stage is an advantage when veterans (seasoned teachers) are utilized in areas such as mentors (National Staff Development Council, 2001).

Considering that the level of support that teachers and administrators receive in learning new practices can be too weak relative to the demands that they face, professional development must be aligned to teachers' needs (Elmore, 2014; Knight, 2009; Lee, 2007) as well as provide

continued support and follow-up (Darling-Hammond & McLaugh, 1995; Guskey, 2002; Guskey and Yoon, 2009; Joyce and Showers, 2002,).

In Guskey's (2002) alternative model that re-examines the process of teacher change he contended that effective professional development programs can facilitate change-making and lead to endurance of change. However, he underscored that the two major factors that hinder effective professional development programs are the understanding of what motivates teachers to engage in professional development and the process by which change in teachers occurs. Rationally, teachers are interesting in professional development activities if they belief that they will gain new knowledge and skills and enhance their effectiveness with their students. But for Elmore the conventional wisdom of professional development captures the knowledge and skill necessary to improve student learning and how people come to master that knowledge (2014). Elmore also averred that the incentives that engage people in changing their practice as well as the resources and capacities that will support the change have to be addressed (2014). However, Guskey (2000) maintained that teachers change their beliefs and attitude only after student learning outcomes have changed as a result of teachers being espoused or introduced to innovation and have employed them in their classroom practices. With the understanding that successful actions are encouraged and likely to be repeated while those that are unsuccessful tend to be diminished, it follows that significant change in teachers' belief and attitudes is contingent upon evidence of students learning (Guskey, 2002).

Consistent with Guskey's (2002) change model, Fullan identified four key elements in his theory that are needed to impact the change process: (a) there needed to be active initiation and participation by all teachers (b) there needed to be pressure and support for change at the local level (c) there had to be changes in teachers' behaviors and beliefs regarding the change, and (d) Teachers needed to feel the ownership of change (1992, p. 25). Further, awareness of how change occurs, and teachers' need for regular feedback on student learning as well as sustained support are critical in professional development (Guskey, 2002; National Staff Development Council, 2001). Guskey (2002) warned about patience in implementing innovations. He recognized that teachers might be reluctant to try new programs or methods due to fear or anxiety, thus, teachers need considerable time and effort to explore new programs for mutual adaptation given the support. With continued follow-up and support in implementing new practices and using them habitually they become a natural part of teachers' repertoire of teaching skills (Joyce & Showers, 2002). Notably a respectful and trusting school culture can resolve issues related to the process of change (Darling-Hammond & McLaugh, 1995; Fullan, 2002; Guskey, 2000; Joyce & Calhoun, 2010; National Staff Development Council, 2001). But the key point that Guskey (2002) emphasized is that a successful implementation can change teachers' beliefs and attitudes.

In accordance, teachers translate theory into practice (Darling-Hammond & McLaugh, 1995; Loucks-Horsley et al., 2003) in the context of professional development, conforms with its

systematic effort to bring about change. For example, Lee's (2007) study provided evidence of how creating new instructional materials and strategies helped teachers translate theory into practice. Lee (2007) presented a professional development model aimed at deepening teachers' conceptual understanding of mathematics content and exposing them to innovative and creative instructional approaches. The program design was based on the belief of several researchers that successful innovations requires acceptance and adoption by teachers. From the evaluation report the program was strong in three aspects that are well documented in the professional development research literature: (1) having multiple participants in a school to serve as a support network, (2) participants' application of instructional strategies in workshops in their local conditions, and (3) the amount of time each participant spent on workshop activities. Lee (2007) suggested that in evaluating professional development programs teachers' professional growth must be measured based on knowledge and using of the knowledge to focus teacher self-assessment.

Student Learning Outcomes

Professional development is an essential component to building the knowledge base of the practicing teacher and their ability to positively impact student knowledge and achievement (Ingvarson, Meiers & Beavis, 2005). The literature on professional development and its potential to improve teaching and learning is resourceful for designing professional development

activities. Unfortunately, these studies are rarely grounded in solid empirical evidence on its effect on practice or intended learning outcomes (Elmore, 2014; Garet et al., 2001). For instance, a study such as Ingvarson, Meiers and Beavis (2005) was more confident about the measures of impact on practice than impact on student learning outcomes.

Elmore (2014) argued that specific professional development should be designed from well-articulated mission for the organization or school system and that the mission should be underlain on some statement on student learning. Hence, teacher professional development is to be tailored to address the difficulties encountered by real students. The content and pedagogy should involve knowledge and methods, that Elmore (2014) described as hard detailed work on the rudiments of effective teaching practice. For instance, professional development efforts in mathematics must capitalize on strategies to engage students to improve their knowledge in the areas that are problematic for them so they can gain mastery in those domains. The enacted practice, therefore, is the content and pedagogy combined in response to student learning needs in specific context as to bring about positive student learning outcomes. In this context, student learning is not limited to cognitive and achievement index but includes the affective variables or whatever evidence teachers use to justify the effectiveness of their pedagogy (Guskey, 2000, 2002).

Importantly, professional development must be used as a tool for building the knowledge and skills of teachers which becomes a link to enhanced student outcomes. In the restructuring of professional development Darling-Hammond and McLaughlin (1995) advocated for the shift from old models of training that are bureaucratic and controlling, to a focus that is on what, when, and how teachers learn and visions of student learning. They proposed that the strategies need to target developing schools' and teachers' capacity to be responsible for student learning. Again, the emphasis is for teachers as both learners and teachers who Darling-Hammond and McLaughlin (1995) claimed will be empowered to become sources of knowledge for collaborative learning in the critical roles as "colleague" and "learner" (p. 599). The new paradigm characterizes teacher professional development as: engaging, inquiry-based, collaborative, connected and derived from teachers' work, sustained and connected to school change (Darling-Hammond and McLaughlin, 1995). Sustaining these attitudes, roles and practices require structures and supports that break down isolation and support risk taking based on powerful form of teaching learning outcomes from belonging to professional communities that extend beyond classrooms and school buildings. Hence, a collective good can be realized based on the value of professional development in fostering the growth of an individual's capacity to positively impact instructional practice in school and school system (Elmore, 2014).

The overall goal of high-quality professional development should be to develop teacher effectiveness in increasing student academic performance (Hirsh, 2009). One reason for the lack

of success with professional development for teachers has been that too much of it does not have enhancement of student learning as the contingency of success (Hattie, 2005) and the one-shot workshops were too general with no connection, guidance and systematic approach (Guskey, 2000). Research show that these should be accomplished using professional development activities that are focused on collective responsibility, aligned with student academic performance standards, coherent with organizational goals, and take place on a continuous basis with collaborative teams of educators involved in ongoing improvement (Learning Forward, 2011; Marzano, 2003; Snow-Renner & Lauer, 2005). Moreover, professional development activities supported by various methods of delivery such as webinars, college courses and workshops that address student learning goals; inadvertently advance ongoing professional development efforts (Hirsh, 2009). Teacher professional learning activities should strive to directly affect classroom instructional practice as well as student academic performance.

Instructional Coaching

Although there is no agreed definition of coaching (Hammond and Moore, 2018) a growing consensus around the benefits of high-quality coaching programs that increase the likelihood of teachers transfer of knowledge to the classroom have propelled interest in this practice (Bush, 1984; Cornett & Knight, 2008; Joyce & Showers, 1982). Joyce and showers (2002) described coaching as team of teachers working on new approach into their instructional practice by providing each other with companionship support to teach appropriately in making

optimal uses of the new model in response to their students and giving ideas and feedback to each other. Hence, the function of coaching is primarily to assist the acquisition of new elements of repertoire once the skills are developed (Joyce & Showers, 1982). A skill is transferred into teachers' active repertoire when it is obtained, however it needs to be transformed (Joyce and Showers, 1982) through processes of critical reflection (Mezirow, 1997). To set the stage for coaching Joyce and Showers (1982) highlighted three techniques: forecasting the transfer process, reaching the highest level of skill development and developing executive control.

Context is important to transfer, hence the classroom conditions including student, content matter, objectives and classroom management should be noted as different from training situation. The key to a successful coaching program is a trusting relationship between teachers and coaches however, training and support from administrators are vital as well (Hammond and Moore, 2018; Knight, 2009). Coaching is confidential, non-evaluative, and supportive. However, teachers usually resisted coaching if they felt threatened by the presence of the coach in their classroom (Borman, Feger & Kawami, 2006). While coaching skills and knowledge are broad, coaches need content expertise, communication skills, interpersonal skills to engage in activities such as lesson demonstration, observation and curriculum consultation (Borman, Feger & Kawami, 2006). Coaches work one-on-one and in small groups with teachers on specific teaching strategies or problems, focusing on practical changes they can make in their classrooms. Essentially, coaching will provide that period of practice until a level of fluidity as existing

repertoire is attained (Joyce & Showers, 1982). On the same vein, Knight surmised the valuable opportunities for teachers to "watch model demonstration lessons, experience job-embedded support and receive high-quality feedback" (2009, p. 509).

Though the research on coaching is relatively bounded researchers (Berlage, 2015; Borman, Feger & Kawami, 2006; Hammond and Moore, 2018; Knight, 2009; Joyce and Showers, 2002) strive to expand the literature. For instance, Bush (1984) in a five-year study of staff development in California examined the impact various approaches to professional development had on whether teachers used new teaching practices. The study revealed that when teachers were only given workshop 10% of them transferred the skills into their classroom practice. When teachers were espoused to workshop and modelling, the teachers who used the skills increased by 2-3%. Notable when teachers were engaged in workshop, modelling, practice, feedback and peer coaching 95% of them implemented the new skills.

Similarly, educational scholars (Berlage, 2015; Hammond and Moore, 2018) have provided empirical evidence of positive outcomes on the impact of coaching of teacher practice and student learning. For instance, Berlage's (2015) mixed methods study that utilized the five levels of Guskey's (2000) evaluation model the findings showed increase in teacher knowledge, use of knowledge and student learning outcomes. Hammond and More, (2018) reported another example of coaching leading to teacher change in instructional practices. The results indicated a

significant, positive and generally linear impact on teacher growth over five coaching sessions based on data collected from observational checklists and interview that were analyzed. The tone of all communications and well-organized feedback were imperative for changing practice. The authors suggested that when schools have a desire to improve student outcomes driven by a moral imperative to change teaching practices to achieve this, teachers respond positively to a formal coaching model. Although the results were not explicit on the impact of coaching on student achievement, the researchers indicated that it was promising based on teachers' growth.

Chapter III: METHODOLOGY

Research Design

This study utilized the conceptions of a program evaluation to examine the impact of the Primary Mathematics Specialist Teacher professional development on student achievement in mathematics at grade 6. This mixed methods case study included both qualitative and quantitative data gathered to better understand the implementation of mathematics specialist professional development, to measure its accomplishments, provide information for improvement for the Ministry of Education, Youth and Information.

Quantitative methods provide numerical representations of outcomes that can be used to assess accomplishment against goals, standards or targets. Quantitative measures of the Professional Development and student performance in mathematics included two sources of data that were examined. The first type of data source was student test scores from the fall and summer 2018-2019 administration of the grade 6 Specialist Model Mathematics Pilot Tests collected from four schools. The second quantitative data source was obtained from observations using a checklist protocol. The qualitative data in this program evaluation were collected from interviews with 12 participants and the researchers' field notes. Secondary source data included training materials, program guide, and the National Standard Curriculum (NSC). Four primary schools in Region 5 in Jamaica were included in this program evaluation. Participants included an administrator, a mathematics coach and a teacher from each school in this study. The

qualitative data were analyzed using thematic coding. The math mean scores from the fall and summer 2018-2019 administration of the grade 6 Specialist Model Mathematics Pilot Tests in the four sites were used as one form of quantitative data in this study to determine student growth in mathematics learning. Observation protocol was the other form of quantitative data used to measure teachers' implementation of the mathematics practices as outlined in the Mathematics Specialist Teacher professional development module. Document analysis was done by means of content analysis to provide the researcher with meaningful and relevant passages followed by thematic analysis to find patterns in the documents. The results were merged to triangulate data strand findings. Data source triangulation compared results of the interviews, field notes, test scores, observations and secondary source documents. Multiple level of triangulation included administrators, teachers and coaches.

Figure 2. Concept Map

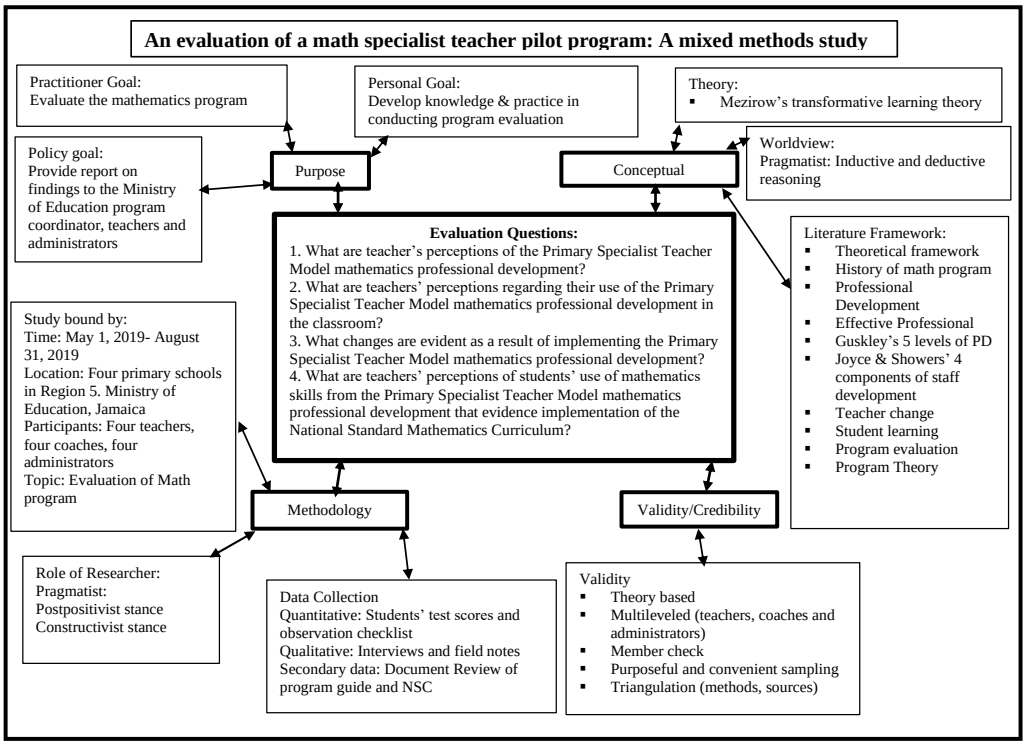

Figure 2. Concept map. Adapted from "*Qualitative Research Design: An Interactive Approach*" by J. Maxwell, 2013, p.5. Copyright 2013 by Sage.

Figure 3. Logic Model

Logic model for the implementation of the Primary Mathematics Specialist Teacher Professional Development

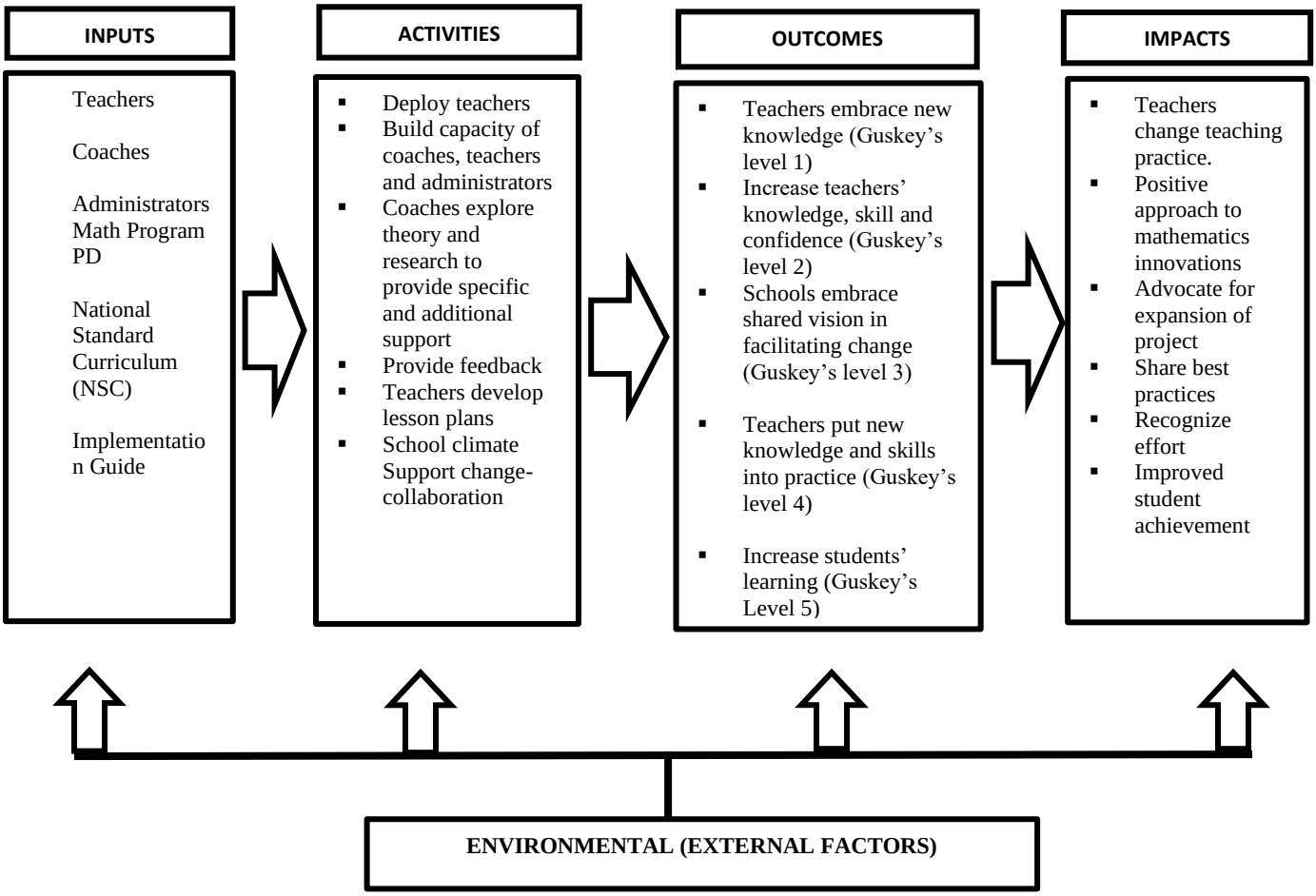

Figure 3. Logic Model. Adapted from "Instructional Coaching Evaluation Using a Realist Approach: A Mixed Methods Study" by Berlage, C., 2015, p.73. Copyright 2015 by ProQuest.

The logic model of the Primary Mathematics Specialist Teacher pilot project in Figure 3 depicts the causal pathway for the inputs, activities, outputs and impacts that were expected to lead to students' improved performance in the mathematics project. The inputs included teachers, coaches, administrators, the NSC and the implementation guide for the project. The inputs were linked to the set of activities that were to be performed for the expected outcomes. The activities were deployment of teachers, and building capacity of coaches, teachers and administrators through professional development. In addition, the coaches explored theory and research to provide specific and additional support to the teachers in understanding and delivering the curriculum. The coaches and administrators provided feedback to teachers and supported teachers in developing lesson plans. From the professional development the school climate was expected to support change through collaboration. Guskey's (2000) five levels of professional development evaluation guided the outcome level to determine the effect of the professional development by examining how teachers embrace new knowledge (Guskey's Level 1), the increase in teachers' knowledge, skill and confidence (Guskey's Level 2), how schools embrace shared vision in facilitating change (Guskey's Level 3), the way teachers put new knowledge and skills into practice (Guskey's Level 4) and increase in students' learning (Guskey's Level 5).

Research Questions

1. What are teachers' perceptions of the Primary Specialist Teacher Model mathematics professional development?

2. What are teachers' perceptions regarding their use of the Primary Specialist Teacher Model mathematics professional development in the classroom?

3. What changes are evident as a result of implementing the Primary Specialist Teacher Model mathematics professional development?

4. What are teachers' perceptions of students' use of mathematics skills from the Primary Specialist Teacher Model mathematics professional development that evidence implementation of the National Standard Mathematics Curriculum?

5. Mathematics Professional Development of the NSC adopted eight mathematics teaching practices for instructional strategies and approaches. Did these approaches promote students learning mathematics as measured by (1) cooperative learning, (2) reasoning and problem solving, (3) posing purposeful questions, and (4) activity based learning?

Intervention

The Ministry of Education, Youth and Information in Jamaica conducted in-service training for teachers during the summer of 2018. It was characterized as a methodology program designed to facilitate and enhance the professional development of grades 4-6 primary

mathematics specialist teachers in two fifteen hours modules in the context of the Jamaican education system. However, over the four days of training only one fifteen-hour module was covered.

The general objectives of the Primary Mathematics Specialist Teacher in-service teacher training was as follows: (1) become aware of the principles and goals of the NSC; (2) design instruction to reflect the principles and skills of the National Standards Curriculum; (3) appreciate the nature, beauty, usefulness and relevance of mathematics in society; (4) apply the theory of constructivism to the teaching of mathematics; (5) develop the pedagogical skills and expertise to enable grades 4-6 students to learn mathematics meaningfully through discovery, investigation and collaboration; (6) recognize that students learn better, make connections faster, remember more, and have fun in learning when they are active participants in the learning process or constructors of their knowledge; and (7) develop conceptual and procedural fluency in the subject area and hence value the discipline of mathematics.

In line with the general objectives were seven learning outcomes required of in-service grades 4-6 mathematics teachers. These outcomes focused on an awareness of the 21st century learners' needs, knowledge of 21st century pedagogical practices and assessment methods for teaching mathematics effectively, incorporating STEM/STEAM in lessons that foster authentic

learning and embracing reflective practitioner. On completion of the training participants were certified to teach mathematics at grades 4-6.

The module focused on providing in-depth analysis of the principles and goals of the NSC to equip in-service teachers with knowledge, skills and attitudes that are needed for them to teach the discipline with consideration of the children's cognitive development. Hence, the training was geared to actively engage teachers in authentic learning of investigating mathematics goals and aims based on the theory of constructivism and its principles: activity based learning, project based learning, cooperative learning, problem solving, developing and using models, hypothesis testing, analyzing and interpreting data, reasoning, planning and carrying out investigations, using mathematical and computational thinking, metacognition, critical thinking, and obtaining evaluating and communicating information.

The facilitators were mathematics coaches and lecturers from teacher training institutions. The Grades 4-6 Mathematics Curriculum, books and online resources were some of the materials that were available for the training. The module consisted of five units, suggesting at least five (three hour) sessions: (1) National standards mathematics curriculum, (2) The Aims, Purposes and Goals of Mathematics, (3) Preparing 21st century Learners: Activity and project based learning in mathematics classrooms, (4) The role of problem solving in mathematics classroom, and (5) Catering to the needs of the learner: differentiated instructions in mathematics

classrooms. For each unit there were general and specific objectives, summary of content terms and concepts. The module comprised three key features: (1) teachers engaged in activities to develop critical cognitive, physical, emotional and social skills, (2) interaction with the grades 4-6 mathematics curriculum and (3) Within a workshop setting over a short period the content, skills and attitudes of the module were projected to be developed.

The training utilized lectures, demonstrations, videos, discussions and small group work. Participating teachers were trained to develop mathematics lesson plans based on the 5Es instructional model with emphasis on problem-based, project-based or STEM approach. Teachers also received training on how to facilitate collaboration between and among students, and how to include project work, the use of hands-on activities, gaming, manipulatives, computer aided instructions and multiple instructional strategies and assessment techniques in their instructions. Teacher training included the modelling of differentiated instructions to cater for the different abilities and learning styles. Presenters demonstrated ways of formulating problem-solving questions and approaches that foster student development of critical thinking skills and confidence in mathematics. The training also aided teachers in designing their classrooms to accommodate varied learning activities, collaborative learning using various instructional materials, resources and tools and the desired atmosphere where students are encouraged to participate and work hard. Teachers were trained to relate mathematics content and skills to real world situations for student interest and engagement, thus scenarios were

presented to teachers at the training for them to develop project work on real life situations for students and rubric for assessing student work.

Demonstrations were done for teachers to develop assessment plan. In groups, participants were engaged in mini lesson demonstrations of skills taught such as differentiate instruction, integration of computer technology in instructions, and instructional strategies that incorporate problem solving and collaborative learning. An attempt to assess the training was through participants' journal and portfolio along with symposium of group during the workshop period.

Teachers who completed the training were identified by the ministry as primary mathematics specialist teacher. These teachers were expected to return to their schools and implement the program in the 2018 to 2019 school year. For the piloting of the program the in-service trained teachers were expected to deliver instruction in two core subject areas (mathematics and science) for 25 contact hours weekly or 22 ½ hours for teachers assigned to shift system (schools that operate two separate shifts: morning and afternoon) and not beyond their allotted contact hours. They were expected to plan, deliver and assess student learning in those subjects across multiple classes within a grade level or to several classes across more than one grade level.

A mathematics coach was assigned to each school to provide coaching support and collaboration for the implementation of the Primary Specialist Teacher Model mathematics program. The mathematics coaches were expected to visit the school where the project was being implemented at least once per week to provide coaching in various areas related to the program such as lesson planning, instructional strategies, collaborative learning, content knowledge, teacher's role as facilitator, student centered classroom, resources, activities, assessment and feedback. Coaches were expected to plan, schedule and facilitate follow-up professional development sessions during the school year for the teachers they coached.

Role of the Researcher

The researcher is a principal within the educational region that the study was conducted and has a good relationship with the principals and teachers at the four sites which facilitated gaining access to information relevant to the study (Maxwell, 2013). However, all participants that were involved in this study were informed and they had a right to agree or not to take part in the study. The researcher's role was an outside observer as she was not employed in any of the schools that were in the study. The researcher embraced a pragmatic worldview during this study. Patton (2015) posited that pragmatism directs researchers to seek practical and useful answers that can solve concrete problems as well as to embrace pluralistic approaches to derive knowledge about the problem. Pragmatism concentrates on "what works" as the truth for addressing the research questions under investigation (Teddlie & Tashakkori, 2009). The

researcher's stance as pragmatist in this study provided multiple viewpoints to ascertain both the qualitative and quantitative findings for triangulation.

The researcher holds an etic stance, being an outsider ascertaining empirical evidence of how the professional development works in attempt to minimize the chance of the researcher's bias in the study. Thus, a postpositivist stance was embraced to collect quantitative data in terms of students' tests scores and observation protocols to determine if the program was functioning as planned. The researcher also embraced an emic perspective in this study garnering an insider's view of reality by way of co-constructing knowledge with participants through interviews and fieldnotes based on the researchers' views, reactions and reflections (Patton, 2015) while visiting the sites.

Bounding the Case

This study was conducted in four primary schools in Jamaica. The research study was bounded by subject area (Mathematics) grade (Grade 6) and program (the Mathematics Specialist Teacher Model) in one educational region (Region 5, of the Ministry of Education, Youth and Information) and one country (Jamaica). The study involved four primary schools and 12 participants, with a grade 6 mathematics teacher, a mathematics coach, and an administrator from each school. Data were collected at the four sites May 2019 to August 2019. The study was bounded by topic: an evaluation of a math specialist teacher program: A mixed method study.

Data Collection

Qualitative data

Field notes was one of the sources of qualitative data that were collected in this study. The researcher made multiple visits to the sites to observe the natural setting, scene and participants over a 12-week period (May 2019 - July 2019). Conducting fieldwork observations at the four sites allowed the researcher to capture teaching and learning activities, behavior, and organizational processes. Particular practices and activities such as lesson planning, instructional practices and teaching strategies, grouping, use of manipulatives and games were observed and documented to determine how the teaching environment fostered the implementation of the Primary Mathematics Specialist Teacher pilot project as it relates to Guskey's Level 3 of professional development evaluation on school support. The researcher, focused on gaining an emic perspective to get an insider's view through co-constructing knowledge gained during the interview and time in the schools interacting with participants and students of what was happening, affirming Patton's (2015) notion that to experience the setting or program from an emic perspective highlights participant observation. Furthermore, observations provided rich, detailed descriptions to support interviews and secondary sources of data. This method of data collection provided direct means of learning about participants' behaviors and the context in which they occur by capturing scenes and making field notes. From the observations the

researcher ascertained tacit understandings of participants' perspectives of what they might not mention in the interviews.

"Interviewing provides the major tool for generating focused for developing abstract conceptual categories" (Charmaz, 2014, p. 87), therefore, interviews were used to garner teachers' perspectives in this research study. Semi-structured interviews with four grade 6 mathematics specialist teachers, four grade 6 mathematics coaches, and four administrators (see Appendix D-F) were conducted in May 2019 to August 2019 at the four sites in the project to capture their perspectives on the effectiveness of the mathematics specialist teacher model pilot project. Semi-structured interviews questions were used to gain insight on what the mathematics specialist teachers, mathematics coaches and building principals perceived of the mathematics specialist teacher pilot project professional development based on Guskey's (2000) evaluation framework. Each category of participants were interviewed with slightly different questions composed by the researcher. A 13 item semi-structured interview question protocol were used to interview the teachers (see Appendix D) and 11 questions were used to interview the mathematics coaches (see Appendix E). The questions developed were related to the focus of the project in terms of the professional development provided using the combination of Guskey's (2000) framework for professional development evaluation and Joyce and Shower's (2002) elements of staff development. Eleven semi-structured interview questions were used to interview the four administrators to capture their perceptions on the impact of the professional

development on the implementation of the Primary Mathematics Specialist Teacher pilot project (see Appendix F). Each participant was interviewed once within 30 to 45 minutes. The interviews were audiotaped and transcribed along with the field notes.

The secondary source of data was characterized as documents. They included the National Standard Curriculum (NSC), teacher training materials and the Primary Mathematics Specialist Teacher pilot project guide. Patton (2015) elaborated that fieldwork also includes finding documents and documentation, thus, establishing the importance of data as a stimulus for paths of the inquiry to drive interviews and direct observations. The artifacts were obtained at the schools' sites during visits over a twelve-week period. Field notes were developed from the findings. However, ethical consideration was embraced in handling private documents. The data were compared to gain deeper understanding in addition to what was seen or heard in observations and interviews.

Quantitative data

The scores for Mathematics Specialist Model Pilot Tests 2018-2019 for the four schools were collected. The NSC was implemented in 2016 to 2017 school year and the specialist teacher model was piloted in 2018 to 2019 school year. The Specialist Model Mathematics Pilot Tests were developed by the Ministry of Education, Youth and Information for piloting the program and were administered in December and June of the 2018-2019 school year in all primary

schools where the project was implemented. The tests focused on the mathematics curriculum. The math mean scores from the fall and summer 2018-2019 administration of the grade 6 Specialist Model Mathematics Pilot Tests were used to determine trend in the data and student growth in mathematics learning over the one year of implementation of the program.

The System for Monitoring Activities, Resources and Teaching (SMART) lesson observation protocol form (see Appendix C) was adapted from the Ministry of Education, Youth and Information for the purpose of classroom observation protocol in this research study. The instrument was created to measure the implementation of the NSC in Jamaica. This form of qualitative data focused on measuring skills in mathematics practices in the categories of planning, facilitation of learning, assessment approach, interactions, and physical environment. The observation checklist is a 25-item instrument using a five-point Likert scale, where1means *not at all* and 5 means *to a great extent*. The mean score for each category was an indication of the extent to which that component of the program was being implemented by the teachers. The grade 6 teacher in each of the four sites was observed to see if their lessons were being delivered based on a student-centered approach where students, collaborate, engage, solve problems, and participate in class. In addition, teachers were observed to see to what extent their lessons include varied learning activities, different modes of instructional strategies and assessments and rich resources to gauge their implementation of the program.

Sampling Criterion

The study relied on convenience sampling in choosing the educational region that the researcher worked as the researcher had insider information about the region and knew the teachers and administrators thus had a good relationship with stakeholders in that region. Multi-level sampling was used to select four school administrators, four mathematics coaches and four grade six mathematics specialist teachers in four primary schools in one region for the semi-structured interviews. Using multi-level sampling of administrators, mathematics coaches and mathematics specialist teachers reflects various hierarchy (Collins, 2010). Purposive sampling was also utilized in choosing the four teachers, one at each site for the observational checklist based on the researcher's judgement in considering that each school in the study had one grade 6 mathematics teacher. Convenient and purposive sampling guided the selection of using the same sites to obtain students mathematics sores and the documents for review.

Data Analysis

Qualitative Data

The transcripts from the interviews and observation fieldnotes were coded for common themes following Creswell's (2009) emergent coding process. The responses were organized in a table by themes with narrative connecting and discussing themes. The interview and field notes transcriptions were analyzed using initial coding. The researcher commenced coding during the data collection period. Initial coding proceeded with line-by-line coding where the researcher

moved through each line of the data to see patterns that might have been overlooked and to engage with compelling events. This action involved the researcher breaking data into categories, defining the actions, determining assumptions, comparing data to data and finding missing data (Charmaz, 2014). Initial codes were compiled into a table with a definition of meaning and presented. From initial coding an insight was gathered which proceeded with focused coding to determine the relevance and conceptual strength of the initial codes by comparing codes. The researcher followed leads to develop theoretical categories, hence, ideas emerged. Theoretical categories were also compiled into a table with a definition meaning and described in a narrative. The theoretical categories were used as a way to organize the results in the study. Here, focused coding allowed the researcher to identify the most salient codes to match large batches of data.

Comparative methods were used to compare interview statements and incidents, and interview statements of different participants. The codes led to asking new questions and to gathering more data, hence, in focused coding the researcher constructed new codes with greater theoretical reach and centrality. The researcher made inferences from codes supported by the data.

Throughout the coding process the researcher engaged in memo-writing to raise the theoretical level of the work. Charmaz (2014) explained that "memo-writing creates an interactive space for conversing with yourself about the data, codes ideas, and hunches" (p. 162). The researcher used memo-writing to develop analytic notes for the coding analysis to

accommodate comparisons between data and data, data and codes, and codes to categories. Thus, the fundamental purpose of memo-writing was to capture the researcher's analytical thinking about the data (Maxwell, 2013). Thematic analysis was then compared to the constructs in the literature.

Secondary source data which included the professional development training materials, program guide, and the National Standard Curriculum (NSC) were analyzed using word-by-word and line-by-line coding procedures to attend to the details in the documents for a thorough analysis. Thereafter, focused coding determined the themes. The data were compared to gain deeper understanding. Coding codes was practiced to see patterns and to think more analytically. Content analysis of interpreting and coding text were done.

Quantitative Data

The data collected from the fall and summer 2018-2019 administration of the grade 6 Specialist Model Mathematics Pilot Tests were compared in this study. This was followed by the observation checklist that was analyzed using descriptive statistics to find out to what extent teachers have implemented the mathematics professional development in their instructional practices. The results were tallied and displayed in tabular form. The math mean scores from the fall and summer 2018-2019 administration of the grade 6 Specialist Model Mathematics Pilot Tests were used to determine student growth in mathematics learning at grade 6 in the four

schools over the pilot period. The results were displayed in tabular form and described in a narrative.

Data Triangulation

Findings from data strands were compared, cross-checked to demonstrate the consistency of the information inferred from the different data sources. Comparing interviews fieldnotes, observations and interviews against documents and test scores were triangulated. Findings from interviewing the three levels of participants (administrators, coaches and teachers) within the organization were examined to identify converging viewpoints on implementation of the program to build evidence to support the conclusions. In summary, triangulation was achieved by comparing findings based on themes from observations, fieldnotes, interviews, document analysis and test scores to determine corroboration or convergence findings to illuminate various aspects in order to draw accurate and valid conclusions about the implementation of the primary mathematics teacher specialist program.

Data Merging

Side-by-side comparison took place with the qualitative findings presented then compared to the quantitative results. This was done using a table to present a joint display (Creswell and Plano Clark, 2018). The convergence of the findings was explained in script with a summary to discuss data convergence, divergence and how the findings relate to each other to produce a complete understanding.

Validity and Credibility

The credibility of the findings was increased by data and participant triangulation and member checking of the findings. This enhanced credibility in providing richness, depth, rigor and breath in the study through multiple methodological practices employed in studying the phenomenon (Denzin, 2012). The researcher met with each participant (teacher, coach or administrator) and shared summaries of the major themes derived from the findings as a form of member check for the participants to validate the accuracy of the interpretations. Findings from interviews at multiple levels of participant in the study sites such as teacher, coach and administer were compared to determine similarities and anomalies to build evidence of consistency in overall patterns and themes or to extrapolate reasonable explanations for divergence.

Chapter IV: RESULTS

This mixed methods case study focused on the effectiveness of the Primary Mathematics Specialist Teacher Professional Development pilot project seeking to improve student achievement. An evaluation of a professional development serves to improve the quality of current professional efforts, and to determine its effects (National Staff Development Council, 2001). The purpose of this study was to utilize the conceptions of program evaluation to investigate the Primary Mathematics Specialist Teacher Professional Development pilot project, to provide clarity on the implementation, and to inform the program manager, the Ministry of Education, and school leaders of the effectiveness of the professional development. Mezirow's (2009) transformative learning theory was the lens used to examine if changes in a teacher's practices, attitudes, beliefs, and perceptions would result in students being competent in mathematics as problem solvers and critical thinkers who are excited and confident about mathematics. The researcher utilized five different instruments to better understand the perceptions of teachers regarding the professional development. They were test scores, observation protocols, interview transcripts, field notes, and relevant documents pertinent to the professional development provided by the Ministry of Education. The research questions that framed this study were as follows:

1. What are teachers' perceptions of the Primary Specialist Teacher Model mathematics professional development?

2. What are teachers' perceptions regarding their use of the Primary Specialist Teacher Model mathematics professional development in the classroom?

3. What changes are evident as a result of implementing the Primary Specialist Teacher Model mathematics professional development?

4. What are teachers' perceptions of students' use of mathematics skills from the Primary Specialist Teacher Model mathematics professional development that evidence implementation of the National Standard Mathematics Curriculum?

5. Mathematics Professional Development of the NSC adopted eight mathematics teaching practices for instructional strategies and approaches. Did these approaches promote students learning mathematics as measured by (1) cooperative learning, (2) reasoning and problem solving, (3) posing purposeful questions, and (4) activity based learning?

This chapter presents the results of the quantitative and qualitative data analysis. One form of quantitative data was the SMART observation protocol used to observe how teachers implemented the mathematics specialist teacher professional development training in their classrooms. Another form of quantitative data was student tests scores collected at four participating schools on two mathematics tests administered to sixth grade students during the first and last terms of the pilot in 2018-2019 school year. Qualitative data included interviews,

field notes, and secondary data sources including the program guide, training materials, and the National Standard Curriculum.

Quantitative Data Results

Observation protocol: The SMART Observation Protocol checklist was used to observe the teaching practices demonstrated by four grade 6 teachers at the four sites in this study. The SMART Observation Protocol (see Appendix C) was created by the Ministry of Education to measure the implementation of the National Standard Curriculum. The instrument was modified by the researcher for this study to measure implementation of the Mathematics Specialist Teacher Professional Development.

The checklist protocol used a five-point Likert-scale instrument divided into six major categories that indicated fidelity of implementing the National Standard Curriculum. Each category had several delineated concepts. These concepts are highlighted in Table 1.

Table 1

Outline of the SMART Observation Form

Major Category	Concept
Planning	Design of lesson reflects careful planning and organization
	Integrated approach evident
Facilitation of Learning	Teacher acts as a facilitator
	A variety of techniques is used to facilitate/collaboration
	Time provided to complete lesson is managed effectively

	Lesson accommodates different learning styles/multiple intelligences and learning abilities
	Lesson accommodates different learning styles/multiple intelligences and learning abilities
	Lesson accommodates students' prior knowledge and experiences
	Strategies used facilitate learning
	Instructional strategies appropriate
	Instructional strategies effectively used
	Instructional strategies varied
Instructional Materials	Teacher uses instructional materials effectively
	Students use learning materials effectively
Assessment Approach	Students are assessed at different stages of lesson
	Useful and continuous feedback is evident
	A variety of strategies is used to measure students' progress
	An assessment plan is used to guide assessment activities
	Teacher's instructional decisions are informed by assessment data
Interactions	Classroom atmosphere encourages student participation
	Students actively participate in classroom activities
	Lesson design encourages collaborative learning approach
	Classroom is a resource rich environment
	The classroom is arranged to facilitate collaborative/team learning
Physical Environment	Physical environment supports student centered learning
	Information Communication Technology (ICT) infrastructure is adequate

Note. Adapted from "System for Monitoring Activities, Resources and Teaching (SMART): Lesson Observation Protocol for Principals and Middle Managers" by Ministry of Education, Youth and Information, p. 4. Copyright 2017 by PMEU/PDD/MOE.

Table 1 indicates the concepts that were used to identify each major category in the SMART Lesson Observation Protocol. The scores, 1-5, were assigned to each concept based on if it was observed and to what degree it was observed. If the concept was not observed, a score of

1 was assigned to that concept. If the concept was observed but for less than 25 of the 60 minutes class, a score of 2 was assigned. If the concept was observed 25 to 39 minutes, a score of 3 was assigned to the concept. If the concept was observed for 40 to 49 minutes, a score of 4 was assigned to the concept. If the concept was observed for 50 minutes or more, a score of 5 was assigned to that concept. Table 2 shows the criteria for assigning each concept a score.

Table 2

Criteria for Assigning Observation Scores

Score	Criteria
1	Not Observed
2	Observed less than 25 minutes
3	Observed 25 to 39 minutes
4	Observed 40 to 49 minutes
5	Observed 50 minutes or more

After the observations had been conducted in each classroom, the researcher determined the mean score for each major category from the SMART Lesson Observation Protocol measured for each of the four teachers. Table 3 indicates these mean scores.

Table 3

Teachers' Mean Scores after Classroom Observations

Teacher	Planning	Facilitation of Learning	Instructional Material	Assessment Approach	Interactions	Physical Environment	Mean Score
1	4.5	4.7	4.5	4.2	5	5	4.7
2	4.5	4.6	4	4.2	4.5	4.5	4.4
3	4	4	4	4	4	4.5	4
4	4.5	4.3	4	4.5	4.5	4.5	4.4
Mean Score	4.4	4.4	4	4.2	4.5	4.6	4.4

Table 3 represents the teachers' mean scores resulting from the observations in the categories of the observation checklist. The rating for each teacher was based on the calculation of their mean score for all the categories on the instrument, with a mean score of 1-1.4 representing "not at all," a mean score of 1.5-2.4 representing "to a small extent," a mean score of 2.5-3.4 representing "moderate extent," a mean score of 3.5-4.4 representing "to a large extent," and a mean score of 4.5-5 representing "to a great extent." Only Teacher 1 obtained a mean score performance rating that indicates implementation was "to a great extent." The other teachers had mean scores that qualified them to fall into the "to a large extent" category for their level of implementation. The highest areas of implementation were Interactions and Physical Environment. However, the lowest area of implementation was Instructional Materials which

measured 4. The data indicated that the mathematics professional development was being implemented by teachers in the classroom to a large extent.

Student Test Scores: The program evaluation was concerned with sixth grade student achievement scores on the Mathematics Specialist Teacher Model tests. Students test scores were collected from two mathematics tests administered during the first and last terms of the pilot in 2018-2019 school year. The mean scores for Term1 and Term 2 for the four schools are noted in Table 4. The mean change in scores for each school is also displayed.

Table 4

Schools Mathematics Mean Scores for Terms 1 and 3 in 2018-2019 School Year

School	Mean Term 1 Score	Mean Term 3 Score	Mean Change in Score
1	49.9 %	49.7 %	-0.2 %
2	42.3 %	56.4 %	14.1 %
3	41.0 %	69.5 %	28.5 %
4	50.1 %	50.6 %	0.5 %
Mean Score	45.8%	50.6%	10.7%

As highlighted in Table 4, Schools 2, 3 and 4 had a mean increase in mathematics scores between Term 1 and 3. The mean change in score for School 1 was marginal while School 2 had a larger mean change in score. School 3 had the largest mean change in score, doubling the mean

change in score for School 2. School 1 had a mean decrease in scores of -0.2 % between Term 1 and Term 3; However, their mean decrease was smaller than the mean increase of their counterparts. The mean score for all schools between Term 1 and Term 3 showed an increase of 4.8 %. The mean change in score for all schools was 10.7%. Overall, the results indicated noticeable improvement in students test scores over the two terms.

Qualitative Data Results

Initial, focused, and axial coding procedures were utilized in the analysis of interviews, field notes from classroom observations, and secondary source data. Constant comparison was used to allow for the most theoretically prevalent themes and categories to emerge (Charmaz, 2014). The results of the data are presented by each strand, with its emergent themes and their operational definition.

Field notes. The researcher constructed field notes from participant observations. The researcher observed a total of eight mathematics lessons at the four sites in the research study. The SMART Observation Protocol checklist (see Appendix C) was used to measure Mathematics Professional Development of the National Standard Curriculum that adopted eight mathematics teaching practices for instructional strategies. The instrument was adapted from the Ministry of Education protocol and was modified by the researcher for the purpose of this study to gauge professional development. The researcher focused on four instructional practices; (1)

cooperative learning, (2) reasoning and problem solving, (3) posing purposeful questions, and (4) activity based learning.

The classroom observations are summarized in Table 5, which highlights the codes associated with this data strand.

Table 5

Field Notes/Participants Observations

Code	Operational Definition
Organizational Support	Organizational support provided for the implementation of the mathematics teacher specialist profession development.
Student Centered	Classroom activities that focus on implementing curriculum practices in which students take active part in their learning.
Differentiated Instructions	Teacher providing instructions that cater to all students learning needs.

***Organizational support*:** Organizational support was a pertinent theme that emerged from the qualitative data. Organizational support has been identified as a valuable attribute for effective professional development implementation (Guskey, 2000). In fact, Elmore (2014) argued that school wide improvement initiatives rely on the commitment of everyone. In the four schools in this study the administrators led the process of redeploying teachers for the Mathematics Specialist Teacher professional development. Administrators and mathematics coordinators attended the professional development along with their teachers and supervised the

implementation process. In house staff development and one- to-one training were held by participating teachers in schools after national training. Teachers were also given support in their local conditions to implement the mathematics specialist teacher model by a mathematics coach. The schools adjusted their timetables to accommodate the mathematics specialist model. The National Standard Curriculum was used as a guide to develop lesson plans in all the schools. The school administrators or mathematics coordinators and mathematics coaches vetted the teachers lesson plans and made suggestions and recommendations to teachers. Professional conversations were held with coaches, teachers, and school administrators in the schools. School wide mathematics staff development were organized and executed as the need arose. In most of the schools the mathematics target scores were posted which inspired all the mathematics specialist teachers to encourage high standards and hold students accountable for their learning. Although the teachers reported that the resources were inadequate, all schools provided some form of resources for the pilot and in two schools, provisions were made for teachers to travel to the training.

***Student centered*:** Student centered was a recurring theme found in the data. Classroom observations by the researcher indicated that all teachers created positive learning climates. All teachers utilized the '5E' lesson plan model of engage, explore, explain, extend (or elaborate) and evaluate. All students were aware of the learning goals and the teachers guided student

activities such as discovering concepts, investigating mathematical situations and problem solving which was primarily through a collaborative effort.

The classroom climate for Teacher 1 was one of high expectations with students' work displayed comprising of individual work and group projects. The class mantra "Change your words, change your mindset" was captioned above the whiteboard, students' individual achievement target for the year posted, a "Bee a Star" chart and "All Star Award" certificates displayed in the classroom evidence the high standard Teacher 1 promoted. Teacher 1 used music to prepare the students for mathematics lessons. Teacher 1 and her students started with their Mathematics theme song "Math, Math" with great enthusiasm and vigor, adding rhythm to the song by clapping. Teacher 1 was energetic, pleasant, and motivating and the students' excitement for the subject was evident. The focus question and objectives of the lesson were read from the white board by Teacher 1 and students. Teacher 1 incorporated the aesthetic subjects in all mathematics lessons. In one lesson, students were given a scenario as a group activity to dramatize road safety practices. Various grouping was done in which students shared their viewpoints with their peers, made decisions about their findings and presented to the class. The teacher allowed the students to discover information for themselves through research using their cell phones and tablets in their group activities. The teacher kept all the students engaged throughout the lessons. A video clip on road signs was included in the lesson and a high level of participation in discussions based on the clip was observed. The teacher posed open-ended

questions at different times throughout the lessons to get students in higher-thinking and to share their understanding of concepts such as “What do you think would happen if there were no traffic lights in our towns?” A few students anxiously responded, “There would be confusion.” Another student responded, “I think we would have several road accidents and the death rate caused by road accidents would be very high.” Teacher 1 provided opportunities for the students to relate their experiences to the mathematics concepts of measurement in terms of speed, distance and time. Furthermore, students were placed in small groups to design and produce ramps from recycled materials for project work, an activity that evidenced integration of visual arts and mathematics as well the development of students’ creativity.

Teacher 4 highlighted the objectives at the beginning of the lesson and guided students in discovery learning, cooperative learning, and problem solving. Students were always engaged in a challenge at the start of the class. Teacher 4 placed students in small groups and gave them Quick Math problems to solve in five minutes. Teacher 4 constantly made connections with prior knowledge by reviewing concepts covered. For example, for the topic “Circumference”, the Quick Math problems was given to the students: a cylindrical water tank has a diameter of 285 cm for one of its circular face what is the total measurement of the radii on the circular faces? The students showed great enthusiasm and determination to solve the questions. Students were open with their answers and willingly explained the process. One group volunteered to put their work on the whiteboard. Throughout the lessons the teacher used probing questions, discussions,

group reports and evaluations to allow the students to find solutions. For instance, in determining how to find circumference, students in groups of four, explored using strings, ruler, tape measure and markers and large spaces. Students used circular objects that were brought into the classroom including tabletops, bucket covers, wall clock and dinner plates. The activity facilitated by Teacher 4 allowed for all group members to actively participate in learning mathematics in a practical and cooperative way by discussing their problem-solving techniques, utilizing manipulatives, estimating, measuring, and presenting. The students in the different groups could be seen busy moving around measuring and recording. The activities involved students giving instructions to each other for example, students told their classmates "put your finger here on the tape". One student instructed, "hold this end of the string, right here on the edge of the table".

Teacher 7 also used the learning objectives to guide students to the expectations in the lessons and meaningfully engaged the students for the entire period utilizing hands on experience, grouping, critiquing and finding solutions. For example, in covering the focus question, 'How do I use my tools effectively in constructing angles?' students watched a short You Tube video on "drawing angles" followed by class discussion about the video. The video was reviewed to emphasize the steps in drawing angles and for observing how the protractor was used. Teacher 7 embraced collaboration by placing the students in pairs to draw and identify four angles given on white board. In that lessons, all students had their tools for class including a

pencil, a ruler and a protractor in line with the objective “to draw and measure angles using the protractor”. The students made an effort to present clean and accurate drawing although manipulating the protractor was challenging for a few students. At that point, Teacher 7 employed scaffolding technique to support struggling students using the protractor to draw a 60º angle on the white board and working with individual student and recognizing their successes. These students were closely supervised and supported by the teacher which helped them to develop the mathematical skills involved. The other students supported their peers as they were asked to review each other work by checking for accuracy. Most students were accurate and those who were not correct they negotiated in their classmates and corrected their drawings. All the students worked cooperatively, and they moved about the classroom freely, comfortably and respectfully participating in the learning experience provided. Teacher 7 provided the affirmation for each pair of students in marking their work and commending their effort. Students were given individual assignment to measure and identify angles from their textbook as reinforcement. The classroom was spacious and well ventilated this contributed to the free movement of the students in different activities, greater and effective collaboration, and the ease of supervision.

Teacher 10 was also observed teaching construction of angles, however, the class was much bigger and space was a challenge. Questioning was used to determine prior knowledge as well as to recap. Teacher 10 engaged students through demonstration in drawing of different angles on whiteboard and clearly explaining the steps involved. However, students were placed

in groups of four to draw four angles in their group where each person got a chance to participating in drawing an angle. The students rearranged the classroom to form their groups by pulling two benches together to face each other while each bench seated two students. Teacher 10 moved around the classroom, checking on the students to see that decisions and drawing of angles involved all four students. The students were excited to choose their own angle. The groups were heterogenous, however, the boys maneuvered the task better in most of the groups and lead the activity. The students were frequently seen supporting each other in the groups by positioning the protractors and guiding students to mark and construct accurate angles on paper. Teacher 10 asked two groups to volunteer to report on their work. The classroom atmosphere allowed the groups to volunteer and speak freely in sharing the procedures to draw their angles.

Differentiated Instructions: Differentiated instructions were found to be another salient theme that emerged from the data. All four teachers utilized different types of assessments to inform their instructions and different instructional strategies. Differentiated instructions was part of the assessments given, particularly in group activities where students were able to negotiate their roles. In this way they were able to choose their area of interest. Flexible grouping practices were employed by all teachers in their efforts to present the same content for student learning. Multiple approaches were employed by the teachers to engage students while catering to their needs. This was observed in activities like singing, dramatization, discussion, designing/creating, viewing, researching, questioning, problem-solving, cooperative learning,

and project-based learning. In addition, Teachers 7 and 10 used scaffolding strategies to address the need of struggling students. Students' work displayed in all the classrooms evidenced the project-based approach and high level of participation in product design. Another strategy that teachers utilized in their instructions as observed in three schools was the integration of information communication technology (ICT) to cater to student diversity. Further, integration of disciples such as social studies and science were also incorporated in mathematics lessons.

Secondary source data. The administrators from the four schools provided documents relative to the pilot project, such as the National Standard Curriculum, teacher training materials, and the Specialist Teacher Model project guide. The secondary sources were coded for themes. Table 6 summarizes the four emergent codes.

Table 6

Secondary Source Artifacts

Code	Operational definition
Organizational Support	Organizational support provided for the implementation of the mathematics teacher specialist profession development.
Professional Development	Ongoing training to enhance teacher competencies in mathematics.
Student Centered	Classroom activities that focus on implementing curriculum practices in which students take active part in their learning.
Student Achievement	Student learning.

Organizational support: Organizational support was a prevalent theme in the secondary data sources and the interviews. The training materials and program guide indicated that students were underperforming in core subject areas including mathematics. As a result, the Ministry of Education, Youth and Information developed the specialist teacher model to aid teachers in becoming proficient in the delivery of these subjects. School administrators were given the task to redeployed teachers to become mathematics specialist teachers. Teachers that accepted the invitation and attended the summer institute were trained to implement the mathematics specialist model in their schools. School administrators ensured that timetables were adjusted to accommodate the implementation of the mathematics specialist teacher model. School administration had the responsibility of ensuring that the implementation of the model occurred in their school.

Professional Development: Professional development was a profound theme found in the secondary source data. Professional development was identified as the activity that engaged in-service teachers in active and creative learning for them to better understand the nature of mathematics and to implement the National Standard Curriculum effectively. The professional development was linked to teacher mathematics competency which was expected to have a ripple effect on their students. Throughout the documents, professional development was discussed as ongoing training that involved a workshop setting and coaching to implement the Mathematics Specialist Teacher model. The module for the professional development focused on

methodology for teaching mathematics aligned to the curriculum. The emphasis was on developing the 21st century skills. A substantive portion of the professional development was about the National Standard Curriculum that promoted project based learning, problem solving and differentiated instructions. Professional development as mentioned in the secondary source documents was designed to provide teachers with the opportunity to participate in activities, interact with National Standard Curriculum, engage in journal writing, and prepare a portfolio on their growth and development.

Student Centered: Student achievement was another salient theme that emerged from the document review. The documents indicated the need for a student-centered learning environment in the schools where the teachers assumed the role of facilitators. Teachers were expected to meaningfully engage students in learning activities aligned to real life experiences so they could construct their own mathematical knowledge and develop skills by being creative, critical thinkers, problem solvers and collaborators. Students were encouraged to develop attitudes as such as perseverance, independence, and digital citizenry. The documents also demonstrated that teachers were encouraged to foster mathematics skills and make connection with prior knowledge. Teachers were encouraged to meet the diverse needs of all students by employing a wide variety of instructions such as project based, activity based, problem solving and cooperative learning. The mathematics vocabulary and the use of information technology were also important in developing communication skills, interest, and confidence in mathematics.

Student Achievement: Another prevalent theme found in the secondary source data was student achievement. Students were expected to become problem solvers, mathematical literate, and able to demonstrate 21st Century skills and competencies. Student learning in mathematics focused on students constructing their own mathematical knowledge through social, physical, and technological interactions with their environment, conceptualizing spatial properties, and manipulating mathematical ideas. Students were expected to demonstrate creative and inventive skills through product design and presentations. Application of knowledge in mathematics to new situations was expected of students. Therefore, the development of interest, confidence, and perseverance in mathematics were critical attitudes that students were expected to exhibit.

Interview Data: Interviews with teachers, mathematics coaches and administrators in the four schools were analyzed using initial, focused, and axial coding procedures. The initial coded data resulted in emergent focused codes. The focused codes were further analyzed by constant comparison resulting into salient themes. Case 1 School had 15 subthemes (codes) resulting from the qualitative interviews; these subthemes were broken into seven major themes. Case 2 School had 14 subthemes broken into six major themes. Case 3 School had 12 subthemes broken into four major themes. Case 4 School had 13 subthemes broken into five major themes. Each emergent theme and its operational definition within the context of this study appears in Table 7 for Case 1 School, Table 8 for Case 2 School, Table 9 for Case 3 School, and Table 10 for Case 4 School.

Table 7

Case 1 School Code Names

Code	Operational definition
Teacher quality	The teacher's competency in teaching mathematics.
Replacement teacher	Redeployed teacher to replace mathematics teacher.
Professional development	Ongoing training to increase teachers' competencies to implement the specialist teacher model.
Comprehensive training	Training teacher to meet an immediate need.
New knowledge	New knowledge teachers gain to improve their teaching practice.
Organizational support	The support provided by the school for the implementation of the mathematics teacher specialist profession development.
Administrative support	The school administrator supports teacher.
Student centered	Classroom activities that focus on implementing curriculum practices in which students take active part in their learning.
Mathematics practices	Mathematics instructional practices that facilitate student centered learning.
Teacher change	Change in teachers' beliefs, attitudes, and approaches when teaching mathematics.
Use of knowledge	Use of new approach in mathematics classroom.
Confidence	Teacher develops confidence in teaching mathematics.
Collaboration	Teachers working together to implement the mathematics profession development.
Common planning	Teachers meet to discuss National Standard Curriculum and develop mathematics lesson plans.
Student learning outcome	Student achievement.

Table 8

Case 2 School Code Names

Code	Operational Definition
Professional development	Ongoing training to increase teachers' competencies to implement the specialist teacher model.
Reactions	Teachers' reactions to the training.
Organizational support	Organizational support provided for the implementation of the mathematics teacher specialist profession development.
Lack of resources	Inadequate resources to implement the professional development.
Modification of timetable	Adjustment made to the timetables.
Collaboration	Teachers working together to implement the mathematics profession development.
Teacher change	Change in teachers' beliefs, attitudes, and approaches when teaching mathematics.
Interest	Attitude and confidence in teaching mathematics.
Mindset	Beliefs about mathematics.
Teacher buy-in	Teacher willingly accepts the change.
Student centered	Classroom activities that focus on implementing curriculum practices in which students take active part in their learning.
Problem solving	Technique used to teach mathematics.
Mathematics practices	Mathematics instructional practices that facilitate student centered learning.
Student learning outcome	Student achievement.

Table 9

Case 3 School Code Names

Code	Operational Definition
Implementation	Influences on the implementation of the mathematics specialist teacher professional development.

Support	Support provided for the implementation of the mathematics teacher specialist profession development.
Subject teacher	Mathematics subject teacher existed.
Schedule	Policy on mathematics schedule.
Professional development	Ongoing training to increase teachers' competencies to implement the specialist teacher model.
Reactions	Teachers' reactions to the training.
New knowledge	New knowledge teachers gain to improve their teaching practice.
Student centered	Classroom activities that focus on implementing curriculum practices in which students take active part in their learning.
Information Communication and Technology	Use of information communication and technology in teaching mathematics.
Facilitator	The teacher allows the students to take control of the learning process.
Student learning outcome	Student achievement.

Table 10

Case 4 School Code Names

Code	Operational Definition
Guidance and support	Organizational support provided for the implementation of the professional development.
Professional development	Ongoing training to increase teachers' competencies to implement the specialist teacher model.
Relationship	Relationship among staff to foster implementation of the mathematics specialist professional development.
Lack of resources	Inadequate resources to implement the professional development.
Reaction	Teachers' reactions to the training.
Drawback	The challenges faced in implementing the professional development.
Teacher change	Change in teachers' beliefs, attitudes, and approaches when teaching mathematics.
Student progress	Improvement in student learning.

Impact	Positive effect of the professional development.
National Standard Curriculum	National Standard Curriculum.
Dialogue	Professional conversation among teachers.
New knowledge	New knowledge teachers gain to improve their teaching practice.
Culture	Norms and practices in a school.

The initial coding phase yield 15 codes for Case 1 School, 14 codes Case 2 School, 12 codes for Case 3 School, and 13 codes for Case 4 School. The codes were from common responses from teachers, mathematics coaches and administrator participants.

The coded interview data were made into code reports that were further reanalyzed at a deeper interpretative level. Several of the codes were merged based on similarities that yielded a total 22 emergent themes, seven for Case 1 School, six for Case 2 School, four for Case 3 School, and five for Case 4 School.

For Case 1 School, the first code group included the themes of teacher quality and replacement teacher. These themes were both categorized under teacher quality. The second code group included the themes of professional development, comprehensive training, and new knowledge. These themes were categorized under professional development. The third code group included the themes of organizational support and administrative support. They were both categorized under organizational support. The fourth code group included the themes of student centered and mathematics practices. These themes were both categorized under student centered. The fifth code group included the themes of teacher change, use of knowledge and confidence.

These themes were categorized under teacher change. The sixth code group included the themes of collaboration and common planning. These themes were both coded under collaboration. The seventh code group included the theme of student learning outcome. Table 11 shows the final seven code groups for Case 1 School, which include teacher quality, professional development, organizational support, student centered, teacher change, collaboration and student learning outcome.

For Case 2 School, the code group included the themes professional development, and reactions. These themes were both categorized under professional development. The second code group included the themes of organizational support, lack of resources, and modification of timetable. These were categorized under the theme organizational support. The third code group included the theme of collaboration. The fourth code group included the themes of teacher change, interest, mindset and teacher buy-in. These were all categorized under teacher change. The fifth code group included the themes of student centered, problem solving, and mathematics practices. These were all categorized under student centered. The sixth code group included the theme of student learning outcome. Table 12 indicates the code groups for Case 2 School, which include professional development, organizational support, collaboration, building teacher repertoire, student centered, and student learning outcome.

For Case 3 School, the first code included the themes implementation, support, subject teacher, and schedule. These were all categorized under implementation. The second code group

included the themes professional development, reactions, and new knowledge. These were categorized under professional development. The third code group included the themes student centered, information communication technology, and facilitator. These were all categorized under student centered. The fourth code group included the theme of student learning outcome. Table 13 identifies the code groups for Case 3 School, which include implementation, professional development, student centered, and student learning outcome.

For Case 4 School, the first code group included the themes of guidance and support, professional development, and relationship. These were all categorized under guidance and support. The second code group included the themes reaction, teacher need and drawback. These were all categorized under drawback. The third code group included the themes teacher change, student progress and impact. These were categorized under impact. The fourth code group include the themes national standard curriculum, dialogue and new knowledge. These were both categorized under national standard curriculum. The fifth code group included the theme culture. Table 14 shows the code groups for Case 4 School, which include guidance and support, drawback, impact, national standard curriculum, and culture.

Table 11

Case1 School Initial Code Groups and Final Emergent Themes

Code group	Themes

Teacher quality, replacement teacher	Teacher Quality.
Professional development, comprehensive training, new knowledge	Professional Development.
Organizational support, administrative support	Organizational Support.
Student centered, mathematics practices	Student Centered.
Teacher change, use of knowledge, confidence	Teacher Change.
Collaboration, common planning	Collaboration.
Student learning outcome	Student Learning Outcome.

Table 12

Case 2 School Initial Code Groups and Final Emergent Themes

Code group	Themes
Professional development, reactions to training	Professional Development.
Organizational support, lack of resources, modification of timetable	Organizational Support.
Collaboration	Collaboration.
Teacher change, interest, mindset, teacher buy-in	Teacher Change.
Student centered, problem solving, mathematics practices	Student Centered.
Student learning outcome	Student Learning Outcome.

Table 13

Case 3 School Initial Code Groups and Final Emergent Themes

Code group	Themes
Implementation, support, Subject teacher, schedule	Implementation.
Professional development, reaction, new knowledge	Professional Development.
Student centered, Information communication and technology, facilitator	Student Centered.
Student learning outcome	Student Learning Outcome.

Table 14

Case 4 School Initial Code Groups and Final Emergent Themes

Code group	Themes
Guidance and support, professional development, relationship,	Guidance and Support.
Reaction, teacher need, drawback	Drawback.
Teacher change, student progress, impact	Impact.
National Standard Curriculum, dialogue, new knowledge	National Standard Curriculum.
Culture	Culture.

Case 1 School Themes:

Teacher quality: Teacher quality was operationally defined as a teacher's competency in teaching mathematics. Teacher quality was a prevalent theme found in the interview data. In general, primary level teachers are expected to deliver a diverse range of subject areas. Findings within research indicated that mathematical and content knowledge is pivotal to effective mathematics instructions. Teachers are aware of the importance of mathematics competencies in their practice and gravitate towards opportunity to develop their subject knowledge. However, teachers are sometimes redeployed to fill a gap without having the required skill set. Teacher 2 evidenced the effort needed to support teachers who were redeployed as mathematics specialist but were not strong in the subject:

> For this school specifically there is a problem because the teachers who were trained to do the piloting migrated, like the grade 6 math teacher. So, they had to pull other teachers

> from other areas at the last minute to fit into those positions and offer in-house training so there was a problem where that was concerned. It required more from me because these teachers really, they confessed that they are not good with the math in many areas and they are just learning, and their stronger areas would have been different subject areas … they don't hold it back in telling you that they don't know how to do the subject and they don't like it. Some are very much willing to learn some are not, so we have an issue there. Miss Jones (pseudonym used for Teacher 1) is just learning the math, but she is a teachable person.

Teacher 1 who was trained in one area of the specialist model but was redeployed to teach mathematics and science. Initially, this teacher seemed to have experienced uncertainty about the professional development and the teaching of mathematic effectively, however, the teacher began to feel more comfortable teaching mathematics. The concept of teacher autonomy became noticeable as Teacher 1 acknowledged her challenges and the growth she garnered from the professional development as expressed by the following quote:

> I taught social studies and science at grade 6. So, I went to Language Arts and Social Studies training for the Specialist Teacher Model in Kingston. After the summer training the mathematics teacher left so I was redeployed as the grade 6 math teacher. My supervisor, the mathematics coordinator provided training... The Primary Mathematics Specialist Teacher professional development has really increased my knowledge in

> mathematics, it helped me to focus on math. For me, the fact that I have never taught math before it has made be a rounded teacher because I do my research to teach the topics and to use the materials. The demonstrations from my supervisor and the math coach have helped me to develop better teaching skills.

Teachers' openness to their colleagues and willingness to learn new strategies created relationships for them to be enlightened, nurtured and supported in their teaching practices. Teacher 3 conveyed that although one teacher did not receive first-hand training in the Mathematics Specialist Teacher professional development the teacher's attitude and quest for knowledge were promising for her practice. She stated, "I guess her own expertise from what she had learnt at college and personality... it wasn't very difficult for her to embrace the approach because she is the type of person who goes out and get information for herself."

Professional development: Professional development was another salient theme that emerged from the interview data of Case 1 School. Professional development is operationally defined as ongoing training to increase teachers' competencies in raising student achievement. Schools ought to be responsive to the needs of the staff. Thus, capacity building through professional development is a generally practice of how schools cope with issues in the classroom. In determining the value of a professional development participants' reactions is one of five critical levels of exploration (Guskey, 2000). Teacher 1 had a unique experience as she received direct training in social studies and language arts and then secondhand training in

mathematics and science. Teacher 1 reflection on the twofold professional development she experienced was notable for the knowledge and skills she garnered that had influenced her confidence in mathematics as explained:

> The training was very informative, I got a lot of hands-on stuff which we don't usually get to do at workshops but it was very hands on and we got a lot of ideas from the other teachers because we were able to present what we had learnt in several opportunities that the professional development provided. Oh, I didn't understand the 5E concept of planning and executing the lesson. I got it at the Language Arts and Social Studies training directly in Kingston and so when my supervisor did the math specialist teacher training with me, I understood it better. I find the 5E model to be very useful in delivering the mathematics curriculum. This is one area that is emphasized in the professional development and in common planning and I think it makes the lessons truly student centered. Also, in planning, I use different modes of assessment and the programme encourages that too. I think this has helped me to realize the various ways mathematics can be taught so that the student can see learning as engaging. It's a good initiative, because it helps me personally to be a better mathematics teacher.

Other teachers shared mixed reactions to the professional development. For example, scheduling was a positive reflection as it allowed enough time for school to restructure and develop staff as expressed by Teacher 3: "It gave us breathing space before school started so we

could make changes and receive training for the implementation. It allowed for in house training before the implementation so the entire school could be ready." However, her disappointment was the duration: "There should have been more hands on, more lesson demonstrations from the persons who presented and so, much of that was not done." Additionally, she stated, "I think enough time was not allotted for the teachers to be trained effectively." Another participant noted time as a challenge even for training and follow up at their school: "The training here was intense…but still the time given to me as a coach in the piloting school was very limited."

Different approaches to professional development occurred to facilitate the implementation of the Mathematics Specialist Teacher professional development. Teacher 1 recounted the in-house training and one-to-one training she received from her supervisor that including active learning and content focus that are two of the major features of professional development (Desimone, 2009, Desimone, 2011):

> My supervisor who is the vice principal attended all the math training in the summer, so she trained me prior to the new school year. She went through the modules and the demonstrations. I did demonstrations for her and it was more of a one to one until we met as mathematics teachers doing the activities and learning more about the content. I remember my supervisor went through the materials with me and she had some authentic lessons and activities on fractions.

Teacher 3 described how training was done at the local level:

> We had in house training prior to the reopening of school. Alright, for the grade 6 teacher, we used the same approaches as the workshop as much as possible. I also passed on through planning, common planning and then at times we would meet and then I would share concepts, best practices that were passed on at the workshop and from my experiences.

Additionally, Teacher 2 explained her role in facilitating training "I look at math lesson plans, I do the professional development workshops with the teachers as well as I do demonstration lessons." These activities are consistent with an active and sustainable professional development.

Organizational support: Organizational support was a recuring theme in the interview data. The literature emphasized that a support system for teachers is widely recognized as an important accommodation for the successful innovations in schools. Participants in Case 1 were well aware of their support systems and capitalized on them. Teacher 1 recounted the considerable support teachers received in various situations in facilitating the professional development as stated, "The school provided a bus that brought us to the professional development in Kingston and took us back." She further stated that, "For each stream in grade 6 we have 1 hour and 15 minutes each day that's 6 hours 15 minutes weekly. I think all the adjustments speak to how the school has facilitated the implementation." Sensitivity to teacher need constituted to the close support one teacher obtained when adapting the professional development as a result of her openness about mathematics as recalled by Teacher 2:

> As I told you the teacher said to me “Miss I am not good at maths but anywhere help will come from” … the VP would come and if there’s a topic the teacher wasn’t strong in, she say ok I’m going to teach that one for you. So, she would go and teach, I mean when I said team teaching among the supervisors and the teachers in the grade it was very excellent.

The profound role of the school leadership in the pilot could also substantiate the interest teachers had in their practice. Teacher 3 put it as follows, “I could say from the administration we have a lot of support and I can tell you the teachers are eager to do the task.”

Student centered: Student centered was another salient theme found throughout the data. Student achievement can be realized when teachers are effective in their practice and committed to student success Garet et al. (2001). Furthermore, Hish (2009) explained that professional development refines a teachers’ effort to utilize instructional strategies that can enhance student learning. As teachers learn, their knowledge is transformed into practice (Avalos, 2011) as a result they are more student oriented in teaching new behaviors to student (Joyce and Shower, 2002). In School 1, a concerted effort was made by teachers to employ a wide variety of strategies in the classroom to modifying approaches that were not addressing student need. Teacher 3 described how one teacher engaged students in her mathematics lessons, “She does more of the problem solving, project based and discovery learning where there is a push for research. Cooperative learning is also stressed in her math class lessons.” Teacher 1 provided an

example of how she allowed her students to take control of their learning by utilizing techniques such as problem solving and collaboration:

> Sometimes they come up with so many different ways to solve a problem when I might never think of some of them and I have to call my supervisor and say "Miss check this out." And this really boost their confidence and they would look at the solutions and say I prefer this way than that and give their reasons. So, my coach and my supervisor always say let them come up with their way of solving the problem and I find they learn from collaborating and the whole cooperate learning takes place in my class every day. I give students worksheet, I use questioning, projects and unit tests and problem-solving activities.

Similarly, Teacher 2 shared that the approaches were seen in lesson planning and they manifested in the classroom where traditional teaching practices were dismissed and creativity, critical thinking and team spirit were honed:

> I see a lot a grouping and hands-on activities. I have to say that the lesson plans were on par because just one teacher was doing the lesson plan, guided by the VP who is also the supervisor for the grade and I see a good effort being made to get the lesson plans more student friendly. When I go to observe lessons, I don't see the chalk and talk, I see the students working in their groups. I see students investigating and problem posing solving taking place. I see a lot of collaboration. The resources were not as many, but I see

> teachers being very creative in getting things made and students using them, I see a lot of that and I also see a lot of team effort.

Teacher change: Teacher change was operationally defined as the change in teachers' beliefs, attitudes, and approaches to teaching mathematics. Guskey (2002) maintained that teachers change their beliefs and attitude only after student learning outcomes have been impacted positively by the innovative practices learnt. One participant assessed her own behavior to the knowledge gained by saying, "I changed a lot of things, because for me I am normally just not thinking about what I'm actually doing; just thinking about student learning and just getting the curriculum, the topics out of the way." Another participant looked at how one teacher adjusted her approach as follows, "She does more of the problem solving, project based and discovery learning where there is a push for research. Cooperative learning is also stressed in her math class lessons." The interest in the subject aroused as teachers became eager to find information and approaches to satisfy student need. One participant summed up changes manifested in the following reflection:

> They had to make some shifts in the teaching mode and we went through all of those training sessions and the shifts they need to make to get out of the lecture method and they had to get into all these techniques where children are involved in their learning. Where this school is concerned, the follow up was very intense, the research was on

going so teachers are constantly searching and in their planning sessions, they are making the effort they are seeking for information, they are looking for new ways I am seeing.

Collaboration: Collaboration was another emergent theme from the interview data. Teacher 2 shared how she dialogued with teachers to enhance the curriculum development, stating:

> I do demonstration lessons with the teachers, we sit in at planning sessions and I give them suggestions and how they can go about, you know, bringing across certain topics I give them strategies that we can use. We do some co-teaching as well. So, we look at strategies that are more conceptually based.

Teacher:

> So, they (other teachers) would network with me and the math coach and she had different sessions with us and we go to professional development with other schools in the Quality Education Circle. Some other teachers who went for training would have given support and we got a lot of ideas from the teachers there. We did a lot of collaborative activities.

Student learning outcome: Student learning outcome was another salient theme from the analysis. The purpose of professional development is to improve educators to raise student achievement (Learning Forward, 2011). Although the literature grounded in empirical evidence

on student improvement is limited (Elmore, 2014; Garet et al. 2001) one participant in this study provides evidence of success:

> "the mathematics specialist model impacted student achievement positively and this is because of the response of the teachers to the professional development because you find that others might have gotten the training but there was no follow up. Most of the assessment activities here were changed, so the students were better prepared to start think critically from September and as a result, you got a better performance. There was a very intense training and approach to change what was taking place as a result I think it benefitted them. They were not negatively affected by the change as much as others would have been. So that did not hinder them from performing well.

Similarly, Teacher1reported of positive results:

> The students are improving. First term, we had a slight improvement, we had a rough time. We had challenges but second term we were better able to bring out the mathematic practices in the lessons, to pull from the students and to get them working cause at first we were thinking about our subject and the student learning in general.

In general, teachers' report on student learning indicated that student achievement was observed in their positive attitudes toward their work and their involvement in class activities. According to (Guskey, 2000) adequate time is needed for the adaption of new practices. Similarly, Teacher 3 summarized student outcome in the following way: "The general observation indicated that

students are very involved in their learning and the teacher is using some effective strategies so student performance will show great improvement over time if the approach continues."

Case 2 School Themes:

Professional development: Professional development was a theme in the interview data. One of the implications for effective professional development as stated by Desimone and Garet (2015) is that teachers vary in response to the same professional development. The reactions from Case 2 participants varies drastically, however, the consensus was that it was meaningful but short. One participant voiced, "the time was too short I think we should have been given more training after that one week. One week cannot assist or help or aid a teacher in getting competent in the area or the specialist area that we are supposed to do." Another participant stated "I feel it was a well-organized professional development except that it was short." She further indicated that the professional development was relevant to their practice explaining, "Well, our feedback is positive, was a lot of reinforcement of concepts and ideas and different approaches to the teaching of the mathematics in the primary school." In summing up the professional development participant said, "I found it informative and practical."

One participant elaborated on the difference with the Mathematics Teacher Specialist professional development in comparison to other professional development:

> This professional development was, I would say, different in terms of getting more training, we got more training cause we now have the assistance of the math coach here

so she's here on a regular basis, probably weekly. It is the first professional development … we have follow ups and someone who coaches us. So, I think this one is good.

Teacher 4 reflected on what he thought was most novel, relevant and surprising in mathematics professional development:

> I think the algebra professional development done by the coach was a very good one, in terms of you know, we are always seeking ways of delivering the algebra content to the students and we have never seen, have never been to a workshop over the years or have ever seen anybody done any form of workshop re algebra and this lady came with her ideas. So this strategy was new to me.

Organizational support: Organizational support represents another theme from the analysis. Organizational support was accessed from different levels of the school by the teachers. The teachers recognized support from their superiors for guidance, clarity, demonstrations, procurement of resources and materials and redefining of policies. Teacher 4 recounted how the implementation process was influenced by the profound support that teachers were able to access in their school withstanding limited materials:

> We came back and we had to use the little that we had and ensure that the lessons were done without help from the specialist model. We got full support from admin. For the first month, we started out on our own and the coach came in after. Our admin, principal

> and vice principal guided the implementation and then the math coach came in and after that now we started to get the support from her.

The mathematics coordinator played a pivotal role in ensuring that teachers were adapting the new approach. Teacher 4 further described how the administration accepted their responsibility in deliberate efforts to encourage successful implementation: “She ensures that we move to the classes on time and tries to give support to the teachers who weren’t doing the delivery properly so she does her little thing by you know demonstration lessons.” Teacher 4 reported of the multiple times the schedule was revised during the piloting by the school leader “The administration adjusted the timetables many times within the year to facilitate the program.” Teacher 6 agreed, “the timetable was adjusted to take on that one.” Teacher 4 explained how that worked, “We have seven and a half hours for math and I think that extra half hour per day works.” It was realized that administrative support is of extreme importance to effect a systematic approach as the mathematics specialist teacher model. Coordinating and managing the system involved guiding decision making and ensuring structures are in place to support change. The acquisition of knowledge and the provision of instructional leadership underpin what administrative support looked like in School 2 as described by Teacher 6:

> As the mathematics coordinator getting the training for the implementation, I do the checks and balance for the full implementation: vetting plans, having one to one with mathematics teachers, encouraging their efforts, doing demonstrations, making

recommendations, and building our teachers competency in planning workshops with the coach. I also analyzed the data then worked with the principal and staff on the way forward.

Teacher 5 clearly expressed her thoughts on support given, “Yeah the school supports the programme, I think the principal along with the VP did a pretty good job in terms of what they expected and so on.” Additionally, the role of the coach added valuable support for teachers to foster the implementation process. Teacher 4 shared how the coach assisted them in their teaching practice: “There were times when our coach supplied us with information content in the WhatsApp group. Sometimes she would have provided us with activities for students just to practice…and she would have helped us with the writing of the lesson plans.” He further described how she embedded professional development into common planning meetings: “We have received from our coaches…few professional workshops at school here, during our common planning time and so forth.” Teacher 5 summed up the direct support she provided as coach: “I give the support and try to share with teachers…on the ground.”

Collaboration: Collaboration is defined as the practice of teachers working together to implement the mathematics profession development. Collaboration was fairly evident among teachers for the purpose of implementing the specialist model. Particularly, collaboration in reference to coaching was a dominant practice among teachers. Teacher 4 explained how the coach initiated collaboration as the thread that linked teachers in networking on common goals

through virtual space: “The coach established the WhatsApp group as a professional group with the school administration and all the math teachers. It was a way of communicating with us and sharing information.” Common planning time was marked at meetings for collaboration to operationalize the professional development as expressed by Teacher 6 who shared how a teacher utilized the sessions for communicating best practices: “whatever he tries in his class, he would share with the other teachers at common planning time.” Common planning also afforded teachers the privilege to engage in professional conversations, as Teacher 6 mentioned, “We accommodate the discussions on mathematics questions and ideas at common planning.” Teacher 5 shared a different perspective of collaboration between coach and teachers, for example: “When I dialogue with the teachers in the class visits I try to get them to see if there is any error in the content that they were sharing and I share additional activities that they could have used”. In addition, clarity of concept and mutual agreement were established in the midst of challenge faced in coaching, evidenced by Teacher 5: “At one point that I didn’t fully understand the model and I had to speak to my coordinator about it but the principal insisted that that’s how she was instructed so we dialogued amicably.”

Another aspect of this finding is that teachers resolved issues through teamwork to ensure smooth and effective implementation of the professional development. One example is shared by a teacher how she worked collaboratively with colleagues to rectify hitches relating to teacher transitioning to different classrooms which was observed at the initial stage of implementation.

Teacher 6 recalled, “I worked hard with the team to resolve the issues we had initially for example, some classes not being covered at a particular time when a teacher would leave that class or she is not arriving on time.”

Teacher change: Teacher change refers to the change in teachers’ beliefs, attitudes, and approaches when teaching mathematics. Teachers and principals alike appear to benefit from professional development in enhancing their effectiveness as educators (Calhoun, 2010; Leaning Forward, 2011). Adult learning emphasizes critical reflection where the learner is autonomous and self-empowered (Merzirow, 2000) in developing new ways of understanding and improving skills (King, 2004). This was the case with Teacher 4, who credited the professional development for sharpening his teaching skills. He reveled in his position and responsibility as well as indicating how he gained experience and developed confidence that enhanced his pedagogical skills, particularly, in lesson planning and instructional practices:

> I am a senior teacher and I supervised teachers before this program came... I am more confident in my delivery of the content since the professional development. I have more ideas of how to deliver the content. I have more ideas of how to prepare my lessons and how to really get across to the students of mixed abilities.

Teacher 6 was optimistic about the Professional Development approaches and was anticipating school wide impact: “He is positive about the new approach and believes he, his students and the school can benefit.” She spoke of how strongly she felt that interest and mindset attributed to

how the teachers responded to the Mathematics Specialist Teacher professional development: “I think the grade 6 teacher has the right mindset as his attitude to teaching mathematics is different from most of the teachers.” She continued to express concern about how teachers were enacting the professional development, “I don’t think the teachers, most of them are embracing the new way of teaching for the students to learn.” The affirmation made by Teacher 4 clearly stated, “the only problem would have been the teachers and their mindset.” Another teacher acknowledged that the inconsistency with the enactment of professional development included teachers’ resistance to change as reported by Teacher 6, “…It would be a teacher problem. The teaching style almost remains the same.” She further shared her observation of how two teachers in the pilot program approached teaching differently:

> So for the other grade 4 teacher who is in the program it is quite the opposite no change and no interest. I would say there is a difference in the teachers when it comes to individuality. The grade 4 and the grade 6 teachers are performing at opposite ends of the spectrum. John (pseudonym) has demonstrated not only competency but the interest and the zeal to make the program work. He is quite interested in the program and you can see the effort in how he delivers his lesson and in conversations, you can see his intimacy with content and delivery method.

In addition, another teacher described teachers resistance to change as follows:

> Many teachers were not willing to take on the change and they were still in that old way of doing their teaching and they sort a drag their feet even in the first weeks when the specialist model started, many teachers went to classes late.

Teacher 4 remained steadfast that the program is promising for teacher growth stating: "The model will enhance teachers in the content and the delivery of the content…" However, the change that is necessary for any program to be effective requires the buy-in by the teachers. Teacher 5 understands that the buy-in from the teachers in a new approach will rely on school wide support stating: "In terms of the PD sessions for the teachers, improving the school's view of math, say mindset changes, this is the thing we can't do the schools have to do it…" School 2 teachers' mindset and interest also influenced how they valued the math coach and capitalized on her expertise to enact the professional development successfully. A climate of mistrust, misunderstanding, fear, discomfort, and doubt was challenged by one teacher who "utilized the coach" and developed "a professional relationship" with the coach. Teacher 4 indicated the variance among colleagues in responding to the support provided by the coach were as follows:

> Not everybody saw the math coach as a support, but I did. The teacher did not give herself a chance to know and to develop that relationship of trust so she could admit her weakness and seek help. I think that person probably she is hiding her weakness and she does not want anybody to know that she is weak in certain areas. She never developed a

relationship with the coach because she fears and maybe she thinks that she was an inspector, evaluating her. She misunderstood what the coach is supposed to be.

Student centered: Student centered theme emerged from the interview data. Student centered as a theme is defined as the classroom activities that focus on curriculum practices in which students take active part in their learning. Effective mathematics instruction requires student involvement and dedication. The teachers were expected to focus on the mathematics practices as they implemented the curriculum. The ongoing support provided by the coach that allowed teachers to model behavior pertinent to student centeredness in their classroom was important for student learning. Teacher 5 stated how she assisted teachers to develop their skills in teaching mathematics for student learning:

> What I did was in line with the National Standard Curriculum, the push for the primary mathematics program as it relates to math practices and so on. I like to try to get them to up the DOK level a bit …say for a grade 2 you could have asked them so and so or you could change the school questioning approach to a math practice 3 if you have a little bit more critical thinking in it so you will share those little things.

Additionally, she discussed strategies the teachers used to foster active learning among students such as grouping, computer aid and instructions, and the use of manipulatives in the classroom: "I know that they try to use group work, manipulatives, so they use a lot of counters and so on. They use their projectors and computers to show videos and that kind of thing."

Problem based learning and grouping were the most consistent form of active learning employed by the teachers in School 2. However, collaboration was a common practice at School 2 but the efforts have been strengthened in response to the training as described by Teacher 6: “teachers were using collaboration widely prior to this professional development and now it is reinforced.” Teacher 6 further explained how the teachers used problem-based learning and collaboration to meet student needs and enable students to tackle challenges and develop critical thinking skills in mathematics:

> What I’ve recognized is that the teachers are using a more collaborative approach. They do a lot of grouping because they are recognizing the different learning styles of varying abilities. During my visits I observed problem-based learning and it is very prevalent at grade 6. For most of the sessions I’ve seen, the teachers do a lot of collaboration or grouping with the students. I notice the students are challenged to think critically by way of the teacher giving the unlimited opportunities to indulge them in problem-based learning. And I see the students looking forward to these engaging tasks and just to come up with their own answers in their groups or individually.

Teacher 4 explained how he implemented problem-based learning. “I used the problem-based approach mostly. I was very consistent in using the problem-based approach. As a guide, I used the projector with all of those problem-based questions… and maybe probe them to get some answers.” In addition, he described how he grouped his students relying and how on the strategy

to increase students' interactions and achievement: "... they collaborate, I ensure that they do that. It's an everyday thing so they develop the skills of working together as their ideas would come out and when they share ideas and make mathematical decisions together they learn more." Teacher 6 added, "There are some efforts of using electronic technology within the classrooms to further enhance the teaching of mathematics."

Student learning outcome: The ultimate purpose of professional development is for student success. The findings relevant to the theme of student learning outcome revealed that all participants were positive about the professional development designed to improve student learning. One teacher reported how he modelled to the coaching strategies to promote student learning: "I think the algebra professional development done by the coach was a very good one. I use problem solving techniques to teach algebra so the students can develop reasoning skills to connect the steps with their solutions." The outcome was impressive as student interest in mathematics and learning took place subsequent to that activity as stated by Teacher 4: "Students gravitate to the math more … I think the students were better able to learn the math concepts." Another teacher recounted that student interest was impacted while the tests data were inconsistent. She stated, "Student learning was evident…They are eager and very attentive. In terms of their test results I would say there was a fluctuation. A lack of consistency, it's pretty mixed. I think it's pretty early." Teacher 5 shared how student development of mental processing skills advanced: "I think the primary mathematics specialist teacher professional development

affected student learning positively…we would deem the model to be a success like in John's classes and so on I think the students are thinking more critically." In contrast, the test results indicated a level of inconsistency as stated by Teacher 6: "In terms of their test results I would say a fluctuation, a lack of consistency, it's pretty mixed." However, this was not a deterring factor for participants, as learning outcomes demonstrate a wide variety of affective variables besides cognitive and achievement indexes (Guskey, 1985). In addition, participants seem comfortable, enthusiastic, and hopeful about the program contending that it is at the early stage of implementation and that it will improve. Teacher 6 declared, "I think it's pretty early." Teacher 4 concurred and added, "I am comfortable, and I want the programme to work and it can work, … I suppose after all the glitches and so forth from this first year, it should work better next school year. We're hoping for the best."

Case 3 School Themes:

Implementation: Implementation was another prevalent theme found throughout the interview data. Implementation is operationally defined as influences on the implementation of the mathematics specialist teacher professional development. Teacher 7 exclaimed that the school wide support facilitated smooth implementation of the program due to the operational system in place: "Oh yes it is a whole school affair! Because even though the specialist model here is partial implementation, if there's any training we don't separate the school to say it is 4 to 6 (grades). We are all involved." In addition, teachers were well informed and the financial

commitment for transportation was made by the school. As explained by one teacher: “We got adequate notice and stuff like that. The school paid transportation for the teachers, I mean, full coverage, everything was provided for you to go.” Teacher 9 agreed that support was evidence at School 3 in enabling the implementation, for example, provision was made at Common Planning sessions for sharing of knowledge from professional development as stated, “We would not hinder her (the mathematics specialist teacher) from sharing. We would provide that slot for her, even though it is slated for something else but because we want the growth not only for her but for all teachers…” She further described how administrative support played an integral role in the enactment of the professional development, “whether it’s assistance in terms of how to execute the lesson or whether it is assistance in terms of you actually taking on certain aspects of the lesson to explain it or it’s assistance to just provide moral support.”

The existence of teaching the mathematics subject prior to the professional development was recognized as a contributing factor to how the implementation process was enabled. However, participants realized that the new approach was more refined, better coordinated and well supported as seen in the following quote from Teacher 7:

> In a sense we did subject teaching from previous years we used to have just for math, just one person teaching math at certain grade…it is seriously pressuring for the teacher because you have to be doing all the subject areas with your class plus you are bringing the other grades math so it can be very pressuring when it’s done that way. For this, we

have a coach who does a number of PD sessions as well as sit in the classes and do observations and give teachers feedback. My supervisor also ensures that the implementation is taking place.

However, when asked about what influenced the implementation process of the professional development teachers expressed concern about the lack of resources to aid them in the pilot. Teacher 7 reported, “I think it is very unfair for the schools because some schools they don’t have internet and for us we have to be pooling to buy materials, but I don’t see many resources that we get from them.” However, teachers were positive about the future about the implementation of specialist model as discussed in the following quote shared by Teacher 8 stated “I believe the model is a worthwhile approach and it will take maybe a year or so to be very effective.” Additionally, the implementation process was influenced by the teacher’s passion for mathematics. Teacher 9, as a supervisor observed one teacher’s passion for mathematics saying, “she walks, eats and sleeps math…she’s not afraid to research.” She further highlighted the collaborative approach “In terms of building” their “own mathematics programme at the school.”

Professional development: The theme “professional development” was pervasive throughout the interview data. Teacher 7 describes her experience of the professional as disappointing “I was looking for something more, I don’t know if I had too much of a high expectation or what. We mainly covered somewhat content and honestly I was looking for

methodology, I didn't see much of that." Teacher 7 also recognized that her needs were not met "I can get my content at your fingertips using the internet … in terms of methodology and like best practices to bring across this area, that's what I need." She further emphasized that "It's the demonstration lessons that are needed." Another frustration shared about the professional development was its ineffectiveness in empowering teachers to improve their teaching practices for evaluations and lack of enhanced student achievement: "I don't think it was that much effective in terms of helping me to be assessed better." Teacher 7 explained that professional development should be based on the data "…Look at methodologies in these areas and I think doing that would have enhanced your development in bringing across the content to the students for them to get a better understanding of the concepts."

Teacher 7 indicated there was not much difference in the Mathematics Specialist Teacher professional development compared to other mathematics professional development: "honestly, I don't see really much difference in the sense than when we have it, it was done on a large scale." Her concern was that "It was basically lecture." Teacher 7 indicated that there was a lack of the adequate opportunity to gain new knowledge "It might refresh and bring back certain things, more like a refresher to me then." Teacher 9 stating: "She would come and say, 'I did this already, some of them are reinforcers'."

Participants shared what they have changed in their instructions as a result of the professional development experiences. Teacher 7 indicated her experience of new knowledge

that she brought back to her local condition: “I know that normally for the key vocabulary, you know you let the children do key word clearing and so on but that was reinforced in the sense so that is something I would really take away.”

Student centered: Students centered was another theme that emerged from the data analysis. Teachers’ awareness of mixed abilities in their classrooms should propel them to exert conscious effort to meet student needs and facilitating an appropriate learning environment. Teacher 8 clarified that “at any given time you might not find a group in the math classroom being set so they would be grouped based on the activity for the day or their abilities and their skill sets.” For example, Teacher 9 shared her observation of how a teacher facilitated learning in her mathematics classroom:

> I remember I assessed her (the grade 6 mathematics specialist teacher) one day, so she went down, she decomposed the objectives again and she grouped the children and she went down to their level and I could see a change, a positive impact, and I tell you some of those boys they wouldn’t learn anything if its abstract learning, they don’t business because she had what they wanted and she was able to break down the instructions and use numerous examples from everyday life, she used things from the environment and so they were able to relate to their experience.

She shared how integration across discipline to optimize student learning in mathematics was performed: “the teacher takes the bird cage from science class to the math class and they (the

students) started looking on angles, they started identifying various angles and measuring the sides." Teachers modified their instructional practices to allow students to deepen understanding and to make use of individual preferences in problem-solving. For instance, students shared power and engaged in student led activities. Teacher 8 explains, "Instructions are now geared towards students discovering, they are now geared towards students investigating, exploring, asking their questions and creating their own solutions …Then based on what they are comfortable with, they will apply that method in solving problems." Teacher 7 also reported that the use of computer technology in mathematics instruction has increased since the Specialist Teacher Professional Development, "It's just that we are integrating more Information Communication Technology, we use more of stuff like that." She also shared how students were encouraged to develop digital skills as she explained how the school implemented policy that supports and manages access and use of technology: "We used to allow the students initially to carry their tablets, now only Grade 6 are allowed to take it and then we have to monitor them to do their research so they would do a lot of research."

Learning outcome: Learning outcome was another salient theme that emerged from the data. Teachers were confident about the effect of the professional development on student learning. Teacher 7 reflected on how student interest and attitude toward mathematics improved "the students are more excited about math class, a teacher cannot miss a math class. They say

‘miss is math time now’ so you find out that everybody is on a high…” A clear description of how students were impacted by the professional development as shared by Teacher 8, stating:

> So you realize now that students are actually talking math now. You will find a set of students who will sit and work the math; you will find that their endurance level has also increased. You will notice that they are making sense of problems; they are now persevering while solving them. So far, I think it has affected student learning positively based on what we have seen in the data.

Student learning was affected positively as indicated by refers students who not only value the subject but became deeply involved in their learning. Teacher 8 shared how students have questioned procedures and results to mathematics problems:

> You hear students asking questions, time past you know, it’s really just teacher says gospel, you hear students asking questions, challenging the thinking of other students. You hear them critiquing each other constructively and based on their critique they would make suggestions, so you find out that the students themselves because of this autonomy that they are given, they are more active in terms of their learning, they are active participants in terms of their learning.

Teacher 9’s perceptions coincided with sentiments expressed about the professional development being favourable to student learning, “I could see a change, a positive impact on the students learning.” In addition, she anticipated greater prospect on student learning as the implementation

progressed “I believe the model is a worthwhile approach and it will take maybe a year or so to be very effective.”

Case 4 School Themes:

Guidance and support: Guidance and support emergent as a theme in the School 4 interview data. Findings emphasized that teachers and administrators continued support and follow-up are essential for learning new practices. Further, when new practices are used habitually with support and guidance, they become a natural part of the teachers’ repertoire of teaching skills (Joyce & Showers, 2002). Teacher 10 described the support and guidance that she received from the coach to enhance her knowledge and practice:

> So, I was confused in terms of the performance task. The math coach told me how to grade the performance task. I was so confused so she took the very first lessons,
> I have three classes of grade 6 and she took the very first lessons and she taught them back to back, form 8 in the morning until 12 noon with just a twenty-minute break. The coach was here every week religiously, we had WhatsApp group, she actually came into the school and conducted staff development, once per month she had math professional development depending on what we needed help with or were struggling with, general planning and in the WhatsApp group, and if we had any issues or questions, we would throw it out in the group and she would respond. She helped us with materials and so. And as usually our principal supports us, so she bought the set of books for us to use.

Teacher 12 stated, "…In terms of resources and support, I am there for them. If they stay late in the evenings, I am here with them. We have the support of the school, support of the parents and of the school board." When teachers work together as a team on new approach into their instructional practice that companionship support is valuable. Teacher 11 described the support of the coaches and how their role enhanced the program:

> Yes, because the coaches are the only person basically who would have been helping the teachers through the implementation of the program, we were there on the ground in terms of support in terms of scope and sequence, support in terms of lesson planning, support in terms of feedback on lesson observations generally. We had co-planning, and co-teaching, and feedback from lessons and PD sessions were held. At least once per week I visited the school and PDs were normally held at least once per term. Apart from having that group professional development depending on the need … we would have that one-on-one workshop.

Drawback: Drawback was another salient theme that emerged from the data operationally defined as the challenges faced by teachers in the facilitating and implementation of the professional development. Professional development can be positive when adequate learning occurs for the participants, however, there are factors that hinder successful transfer of knowledge and skills into the classroom. Financial budgeting can impede the efforts to successfully implement new educational initiatives at the local level. Teacher 12 stated: "The

only drawback I have is that I don't think we have gotten the financial support as a school that is piloting the program." She further explained the constraint on funds to meet the demand of the pilot, in particular, full implementation at her school required extensive support and vast resources. She stated that "The copier wasn't working and I had to buy a new one to satisfy the demand of the specialist model … it is in full implementation here at grades 1 to 6 and you can imagine all of that printing."

Participants also shared their frustrations about the professional development. For example, Teacher 10 expressed that "The Kingston training was kind of confusing.... I thought that one trainer in Kingston was a waste of time." She further reflected on the presenters stating, "I thought the ones that we got that facilitated math they were not ready". Another teacher indicated the workload teachers carry while expected to effectively implement a new initiative was difficult. Teacher 11 discussed how she thought teachers were overwhelmed in transitioning to the program while having to teach the aesthetic subjects. "Having to carry this specialist model, having to carry these specific subjects (art, music, drama, and visual arts) and still having to teach those other classes caused some additional pressure." She stated that "Integration is something that has been discussed" and "something teachers have been going to workshops for" but there is no policy for the "integration concept." She further clarified that "For the school I was, they were discreetly timetabled."

Culture: Culture is the norms and practices that exists in a school. Literature cited in this study accentuated that a respectful and trusting school culture can address issues related to the process of change (Darling-Hammond & McLaugh, 1995: Fullan, 2002). The existing culture at School 4 embraced the mathematics subject teaching approach. Teacher 10 reported on their practice and the new approach, "… Our school had always have streaming, always had teachers focusing on specialized areas rather than teaching all the subjects, at the time I thought we were already doing so I don't know if there is any difference." Teacher 12 also opined that the previous approach to teaching mathematics in their school should influence the implementation:

> We use one math teacher for Grade 1, one for Grade 2 and the teachers were trained so when we got to this now, the specialist model, we already had teachers teaching the subject across grade it's just to pair it, pair the math with the science because we didn't have that before but we had the math base from a long time. The approach isn't new. Therefore, the implementation process was smooth.

National Standard Curriculum: National Standard Curriculum was another relevant theme that emerged from the interview data. The intent of professional development was to enhance professional knowledge, skills and attitudes of the principals and teachers in order to raise student achievement (Guskey, 2000; Leaning Forward, 2011). Hence, the Mathematics Specialist Teacher professional development was geared toward capacity building for the outcome of student achievement. Teacher 12 shared how she valued her role as a school leader in

her acquisition of knowledge on the implementation of the National Standard Curriculum through professional development sessions including the Mathematics Specialist Teacher Model:

> As the Principal, I am part of the implementation team. I gained the knowledge of how to write the lesson plan and how to guide them because I went to the NSC training.
>
> I have been all over the country for the specialist training. In Discovery Bay, in Kingston, everywhere they have it. I have never missed any of the trainings for the programme.

Literature cited in this study refers to the fundamental elements pertinent to professional development including active learning, teacher learning and content focus. The Mathematics Specialist Teacher professional development was aligned to the National Standard Curriculum and offered meaningful engagement as reported by Teacher 10:

> More of lesson planning was done in line with NSC than before. In truth and in fact, the guidance and the practice in writing the math lesson plans were very helpful because at that point it would have been my first year at grade 6 and being introduced to writing the 5E lesson plans and I have never written a 5E lesson plan until the workshop so that was very helpful. So the guidance and the practice that we got for lesson plan was really good.

In addition, Teacher 11 highlighted ways in which the National Standard Curriculum was utilized:

> You know the NSC itself comes with suggestions in terms of student learning. We would have covered a lot of suggestions there, so you found that teachers were actually making

use of them and even the availability of lesson plans and so on that were posted by the NSC. Teachers were actually utilizing them and modifying them to suit their needs.

Impact: Another pervasive theme that emerged from the data analysis was impact, operationally defined as the positive effect of the professional development on teachers and students. The general understanding is that effective professional development should develop the teacher capacity to positively impact instructional practice in the school. Teachers need to learn more about their subject area and how student learn as they engage in professional development. Adult learning theories also promote a deep understanding, hence teachers require reasonable time and effort to explore new programs for mutual adaptation. The influence of the professional development on teachers can develop interest and positive attitudes towards deepening knowledge and skills when developing their pedagogy as seen in the reflections of Teacher 10:

> I am just constantly studying, every night I study the math to come and teach the next day don't matter how I think I know it I have to do some work. I actually study like the children. I have to go through the targets and I have to know the content. As a matter of fact, I realized the need I had and I tried to build on that area…Literally, I do my work to bring across my lesson effectively. I have seen improvement in the grades so the students learning would have been positively impacted so to speak. They embraced the approach,

> all my students were involved and they made progress in their class work and most of them had the right attitude towards mathematics.

Similarly, Teacher 11 explained how teachers used the mathematics instructions from the professional development:

> I said it would have been more student related even though more problems could have been seen but you see more concentration in the getting students involved, they are doing more research to get ideas of how to bring across certain concepts so you would have seen them using their group work, a lot of grouping and group activities. They would have done more collaboration, more of that was seen in the classroom. I think teachers tried to bring across the curriculum in the most practical way they could and the students' responses indicated their interest in learning what was being taught.

The teachers used various approaches to enhance the students critical, collaborative and creative skills. Teacher 12 reported on the ripple effect the professional development had on teachers and student learning:

> They really improved and when you sit in the class, you see the teacher giving them the questions. I was talking about the critical thinking, so when the teachers go to do the research now and they find something interesting, they are not going to come with it like that, they are going to fit it to their own use. They might add something or remove

something, modify to their own use to make it meaningful and I see them doing a lot of quizzes, pop quizzes when they go to classes... They get the students to do group activities to get out the collaboration cause it happens in the classroom among the student and between the teacher and the students. I see more project work being done in mathematics and I realize how creative the students are as they manipulate the resources and do their own thing, use their ideas. It affected the students positively.

Cross Case Analysis Results:

There was considerable overlap among themes and participants responses in the cross case analysis of the four school cases. The cross case analysis are represented in five individual categories with similar occurrences in all four schools.

Organizational support: All four schools devoted extensive support to facilitate the implementation of the Mathematics Specialist Teacher professional development. Organizational support was a dominant feature relative to a school wide culture where buy-in by participants into the program was evidenced by the considerable support teachers received in implementing the program. Further, vice principals and senior teachers provided moral support and coordinated the program. Initially, all schools performed due diligence in preparing teachers for the Summer Institute. However, only two schools absorbed the transportation costs for teachers travelling for the training. The

four schools in this study made adjustments to accommodate the professional development in their structure such as whole school sensitization, in-house training and modification of timetables. In addition, all schools managed to secure common planning time for a significant amount of collaborative work among teachers to plan lessons, and to share best practices and provide feedback about the training. For example, in one school, all mathematics teachers met and shared in the mathematics curriculum development and teaching practices. Notable was the common planning time utilized by the mathematics coach. Another, common occurrence among the four schools was inadequate resources for the programs.

Professional development: All four schools in this study attended the Mathematics Specialist Teacher professional development and received training. However, in one school, the grade 6 mathematics teacher received second-hand training. The teachers across the study shared disappointment and frustration about the content of the professional development as they either had different expectation or they thought the duration of the professional development was too short. The schools found out about teacher coaching saw it as a new experience in the professional development however, all schools capitalized on the coaching instructions. The participants found the coaches to be supportive and knowledgeable. The teachers indicated that the coaches were organized and the professional development helped to bolster teachers' mathematics pedagogical

skills. Overall, all schools found the professional development to be meaningful as teachers were able to make changes to their instruction practices based on new knowledge.

Collaboration: Collaboration was prevalent in the schools, however, only in two schools was collaboration highlighted as a theme. Common planning meetings were one way in which all the schools fostered collaboration to enhance the implementation of the professional development program. Collaboration was evident in the establishment of a network that coaches had in the schools. Further, the coaches had dialogue with the teachers at the schools during and after class visits. Similarly, the coordinators in the schools collaborated with the teachers to ensure smooth implementation of the professional training and activities.

Student Centered: The participating schools employed the strategies that promote student engagement and active learning which were aligned to the strategies embedded in the curriculum. All schools used grouping, problem based, project based, and real life experience with various assessment activities to enhance a student centred learning environment. None of the schools deviated dramatically from the curriculum. Although the four schools did not have the same resources, there were inconsistencies in

approaches, and differences in specific instructional practices as determined by each school context.

Impact: The impact of the professional development demonstrated that teachers and student increased their mathematics competencies. For example, all teachers used their new knowledge and became confident and demonstrated autonomy in the delivery of the mathematics curriculum. All schools reported that there was a positive impact on student learning, particularly, increased interest and confidence, and determination to solve mathematical problems. Based on the confidence teachers developed in mathematics coupled with positive student behaviours, the schools are optimistic about student achievement and the future of the program. Teachers associated positive impact of the professional development mathematics program on student achievement and their own teaching praxis but also noted continued resistance to change by some who received the training.

Cross Case Analysis Summary:

This case study was conducted to determine the impact of the implementation of the Primary Specialist Teacher Model for mathematics in four primary schools in Jamaica. The findings from the cross case analysis provided insight about the mathematics pilot project in multiple schools to inform the program managers, the Ministry of Education, school leaders,

teachers, and mathematics coaches. The study successfully investigated teachers' perceptions of the mathematics pilot project that can be used to make informed decisions about professional development in the future.

This chapter summarized the test scores, observation protocols, interview transcripts, field notes, and relevant secondary source documents pertinent to the professional development. The instructional practices employed in the four schools paralleled the professional development program and the findings revealed that all schools supported the professional development training, organized teachers in collaborative work groups, and provided time for teachers to reflect on their practices and adopt new strategies which in turn enhanced student learning.

Chapter V: DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Increasingly, mathematics teaching and learning continues to gain significant attention. Learners are expected to develop the necessary competencies to function in society by embracing 21st century learning skills and becoming prepared for the demands of citizenship, college, and promising careers in math and science. Professional development to support student learning is expected to improve teaching practices, enhance teacher quality, meet student needs and close the achievement gap. The Primary Specialist Teacher Model was proposed by Jamaica's Ministry of Education Youth and Information. In 2018, teachers acquired in-service training at the Summer Institute in mathematics and science or language arts and social studies. Considerable resources were invested in the professional development workshops, however, to date, no systematic study of the mathematics program has been done. It was critical to evaluate the mathematics program and accompanying professional development to determine if the intended outcomes of the program were achieved.

This study utilized the conceptions of a program evaluation to determine the impact of the implementation of the Primary Specialist Teacher Model for mathematics in four primary schools in Jamaica, to provide clarity on the implementation, to inform the program managers, the Ministry of Education, and school leaders of the effectiveness of the professional development. Mezirow's (2009) transformative learning theory that framed the study was the

lens used to examine if changes in a teacher's practices, attitudes, beliefs, and perceptions resulted in students being more competent in mathematics as problem solvers and critical thinkers, excited and confident about mathematics.

Discussion of the Results

Discussion of the results focused on three major questions from the interview protocol that were used to elicit teachers' perception of Primary Mathematics Teacher professional development across all four schools.

(1) How do you describe the Primary Mathematics Teacher professional development?

Professional development is expected to provide teachers with an experience through myriads of activities and interactions that can increase their knowledge and skills, improve their teaching practice, and contribute to their personal, social, and emotional growth (Cohen, McLaughlin, & Talbert 1993). The results of the data analysis showed that, of the twelve teachers interviewed in the four participating schools the general consensus of the participants was that the professional development was well organized, fully supported, meaningful, and benefited them substantially. For example, one teacher shared her perspective by stating: "I found it informative and practical." Several responses from the participants also augmented the growth and development in mathematics content and teaching skills that they garnered from the training. In addition, participants also recognized and embraced the coaching instructions provided in the professional development as stated in the following quote:

> This professional development was, I would say, different in terms of getting more training, we got more training cause we now have the assistance of the math coach here so she's here on a regular basis, probably weekly. It is the first professional development … we have follow ups and someone who coaches us. So, I think this one is good.

Conversely, the findings also revealed that the professional development was too short, and the needs of the teachers were not addressed. Participants suggested that more demonstrations, differentiated instructions and resources should be included. Participants also indicated lack of confidence in the presenters. For instance, one participant stated that, "There were different instructors for the different subjects because when I asked the other groups, they said their instructors were ok. So, I thought the ones that we got that facilitated math they were not ready." As espoused by Desimone and Garet (2015) these findings affirmed that teachers vary in response to the same professional development.

Evaluating the effectiveness of professional development that includes the participants' reactions is critical. Hence, professional development should focus on teachers' needs as Desimone (2011) emphasized providing opportunities to address teachers learning needs and embedded ongoing implementation are part of the priority of professional development. Hirsh (2009) postulated that it should provide coaching for successful implementation. Five main features of effective professional development includes content focus, active learning, coherence

, sustained duration, and collective participation (Desimone, 2009; Desimone, 2011; Desimone & Garet, 2015). However, based on the findings of this study, there were gaps in the professional development as indicated by the participants reactions. Notably, there were significant gains by the teachers from the professional development as indicated by numerical scores. The common perception of the professional development was that it was purposeful and positively impacted teachers' beliefs, knowledge and skills.

(2) How have your knowledge been enhanced by the Primary Mathematics Specialist Teacher professional development?

The findings from this study indicated that teachers in all participating schools gained new knowledge from the Primary Specialist Model mathematics professional development. Participating teachers appeared to benefit from the professional development as reflected in the overlapping in themes of teacher quality, teacher change, student centered approaches, and professional development. Teachers adopted the mandated program and the knowledge from the professional development transferred into practice. This was evident by the overwhelming positive responses from teachers about the effect of student centered approach to teaching mathematics. The multiple instructional practices employed to facilitate learning were apparent across the cases. Participating teachers were also passionate about particular aspects of the professional development that they found most useful and relevant. This included lesson planning, demonstrations of lesson about algebra, and use of mathematics vocabulary. One

participant shared how lesson planning enhanced her in implementing the National Standard Curriculum stating: “I find the 5E model to be very useful in delivering the mathematics curriculum.” Teachers have used many aspects of the professional development and have gained confidence in their practice. Teachers’ improvement in knowledge and skills were consistent with the literature which coincides with Guskey (2000) who stated that professional development is fundamental in strengthening the professional knowledge, skills, and attitudes of educators.

(3) In what way has the Primary Mathematics Teacher professional development influenced your teaching practice?

The findings from this study showed that organizational support, a dominant theme in the data, catalyzed the changes made to the structure of the four schools. The schools modified their timetables to accommodate the math program, redeployed teachers, accommodated in-house training, facilitated intensive Common Planning sessions, provided close supervision of mathematics programs and curriculum implementation, and supported peer coaching.

Overall, the teachers have made a concerted effort to implement the strategies learned during the professional development and have accessed the support and guidance provided by their coaches and their supervisors. The teachers reported that they have experienced favourable responses to the strategies from their students as they employed a more student centered approach to mathematics instructions.

The findings from this study support the theories about professional development that teachers learn and transfer knowledge into practice for the benefit of their students (Avalos, 2011; Hirsh, 2009). The findings from the cross case analysis further affirmed Guskey's (1985) position that teacher change in beliefs and attitudes when they implement innovations that cause student achievement to improve. The professional development training appeared to be connected to students' needs and was highly relevant to the classroom outcomes. The teachers found the innovations discussed in the Professional Development training to be practical hence they could make the transfer of knowledge and skills to their own classroom. Findings from the measures and thematically coded interview data helped validate Desimone and Garet's (2015) fundamental concepts of a successful professional development that is explicitly linked to highly effective classroom instruction.

The teachers who received the professional development training appeared to change their beliefs, attitudes and practices that impacted their teaching praxis. This was evident in the observations of their mathematics instructions including modification of their physical classrooms. These changes appeared in the emergent themes in the final analysis of the coded data and included findings about differentiated instruction, and student centered instructional practice, also supported by the thematically coded field notes, observations, test scores, and interview data.

However, teacher resistance to change was also revealed. While the majority of the teachers utilized the coaching support and encouraged a supportive relationship it was difficult to alleviate fear and mistrust at some point with the teachers. Most of the teachers employed student centered approach to teaching mathematics and assumed the role of a facilitator in the classroom. This ensured that power was shared between the students and the teacher. Mathematics lesson plans were developed from the National Standard Curriculum based on the 5E model where the teachers made learning interesting and goal oriented. Observations revealed that the teachers utilized student led activities and were deliberate in their efforts to fully engage all their students through discovery, project based, and cooperative learning. The teachers also found value when integrating real life experiences and technology with other disciples in the mathematics lessons.

The researcher's observations of the teachers revealed that the mathematics classrooms were supportive and that the teachers included differentiated instruction in their practice and assessments. Struggling learners were supported by their teachers through scaffolding and individualized attention as they were trained in the Professional Development. The opportunities for students to collaborate and interact with others while constructing their own mathematical knowledge facilitated by the teachers were seen in the observations. The climate of their classrooms was supported, recognized, and valued by the students who were free to share their views, suggest alternative solutions, and pose questions in their mathematics classes. The field

notes and observation protocol data provided evidence of the strategies learned during Professional Development as demonstrated in the classroom of student learning targets, reward charts, students' projects, and mathematics kits.

The themes of organizational support, guidance and support, culture, collaboration and implementation overlapped in highlighting the system support in the schools that promoted the implementation process in order to sustain the program. Further, interview, field notes and secondary source data revealed that the transfer of knowledge from the professional development that occurred in the schools was a result of the backing provided by the school systems based on the high level of awareness, relationships and commitment at the sites. Teachers gained autonomy in several areas of their mathematics instructional practices including the opportunities to collaborate. In turn, the teachers afforded their students similar opportunities to gain confidence, develop interest and become competent in mathematics. The findings were analogous to other researchers who documented positive teacher change relative to professional development.

The study revealed that teachers saw students embraced and used their mathematical skills from the training that were derived from the National Standard Curriculum. Students were engaged in research, cooperative and appeared to the teachers to be discovery learning. The students also learned about problem solving and appeared to be interested in constructing their own mathematics knowledge. For example, one teacher explained how students responded in

problem solving activities by stating; “Sometimes they come up with so many different ways to solve a problem …” The findings emphasized that grouping was a very dominant feature among students in their mathematics engagement, where social interactions were fostered. In addition, teachers reported that students developed skills of investigating and problem posing.

The teachers realized that students have become more interested in mathematics and confident in the mathematics discourse. The teachers indicated that the students became excited about mathematics and displayed positive and persevered in their approach to problem solving. Considering the positive impact that the program had on student learning, the findings revealed that the program was well supported by the schools and is expected to continue as it held great promise to enhance student success in mathematics.

Sustained change in instructional practice largely depends on a shared understanding about the nature of the innovation and what it can accomplish (Joyce, Showers & Bennet, 1987). This was the case with several participants in the four schools who credited the professional development for sharpening their teaching skills. In the interview data, teachers mentioned how they gained experience and developed confidence that enhanced their pedagogical skills, particularly, in developing lesson plans and instructional practices.

Relationship to the Theoretical Framework

Findings from this study demonstrate that transformative learning theory that provided the lens to determine the impact of the implementation of the Primary Specialist Teacher Model for mathematics in four primary schools in Jamaica was apparent. Teachers critically reflect on their practice and realized the need to gain new knowledge about mathematics in their classroom. The professional development addressed context, condition and learners' experiences (King 2004). Dialogue was fundamental during the implementation process where opportunities were given for teachers to learn, share ideas and support each other. This dialogue included during class visits, common planning, and one to one training. Dialogue between the facilitators of the professional development and teachers fostered involvement, engagement, and trust. These practices are consistent with transformational learning theory.

The findings from this study support previous research that utilized the transformative learning theory to investigate adult learning. Transformative learning theory can be put into practice to deepen understanding on how mathematics professional development is implemented and how knowledge is transferred.

Conclusions

An evaluation of a professional development serves to improve the quality of current professional development efforts (National Staff Development Council, 2011). Mezirow's (2009) transformative learning theory informed this study and the findings revealed that the mathematics program was successfully implemented, and moderate program outcomes were

achieved. The study also revealed that administrators, coaches and teachers perceived the implementation of the professional development as positive and appeared to improve students' skills to learn mathematics in all four schools. The findings support effective professional development, which is content focused, coherence, encourages active learning, is sustained for reasonable duration, and collectively benefits the participants (Desimone 2009, Desimone, 2001, Desimone & Garet 2015).

The teachers found the professional development to be meaningful and practical and voiced that their content knowledge, praxis, and confidence were impacted. Teachers recognized their need for the professional development and value it improves their pedagogy. The professional development was helpful for teachers seeking to modify their instructional practices in the mathematics classroom. They became more comfortable and confident in teaching mathematics utilizing student focus activities and problem solving techniques. The teachers embraced more interactive student learning approaches as a result of the professional development. The findings were consistent with the literature that professional development works to influence teacher knowledge and beliefs, classroom practice and student outcomes (Guskey, 2000).

Clearly, organizational support, teacher guidance and collaboration were critical in the implementation process. School administrators provided that leadership and support that

connected the priorities between the school and the Ministry of Education to sustain the program. Teachers also valued and appreciated the support from coaches as they expressed how they fostered a professional relationship through coteaching, modelling, dialogue, feedback, and common planning. However, if teachers were more involved in professional development decisions and their needs and interest were considered, the results would have been more positive. Teachers need to feel a sense of ownership to commit themselves to professional development leading to change (Fullan, 1992; Obara & Sloan, 2010). When teachers are included in professional development planning and their needs are aligned (Elmore, 2014; Knight, 2009; Lee,2007) and they feel confident to attempt and to embrace new strategies.

In summary, the overall benefit of the professional development was significant as teachers changed their beliefs about mathematics practices which further enhanced students' interest, confidence, and participation. The participants in this study voiced that they were impressed with student achievement and strongly believed that greater success would be possible if the program continued.

Implications of the Study

Two important implications that could be derived from this study would first be the discussion between the Ministry of Education and the program manager to expand the program to other schools. The pilot project created numerous, positive impacts and shifted teachers'

approach to teaching mathematics to be more student centered, aligned to the mathematics curriculum and potentially increased student interest and participation in mathematics. Second, the opportunity to maximize collaboration among teachers permeated the findings of this study. Through collaboration, teachers shared their viewpoints concerning teaching, learning, and understanding of classroom practices. Collaboration should be promoted in different ways including professional learning communities, common planning and peer coaching. These opportunities allow teachers to gain clarity, refine their practices, and to discuss what works when innovations are introduced. Teachers valued interactions they share with their colleagues through feedback and support. Collaboration fosters trust and relationships and enhance collegiality for the good of the students within the organization. This study supports Elmore's (2014) idea to dismantle isolation and encourage dialogue beyond the classroom and school building lead to collective accomplishments.

Limitations

A major limitation in this study was to conduct a program evaluation. Due to the small sample size of this study the researcher was unable to demonstrate a causal pathway for the mathematics program. However, the conceptions of program evaluation were utilized to establish this case study.

Another limitation in this study was the inadequacy of student test scores in capturing student performance at the beginning and at end of the implementation process. The test scores were collected from tests administered to students during the piloting of the program. Having pre and post test scores for the students would have clarified if student achievement improved as a result of the professional development.

The final limitation was that only two schools fully implemented the specialist model. Partial implementation involved only grades 4 to 6 while full implementation took place from grades 1 to 6. Full implementation involved more stakeholders and stronger system support.

Recommendations for Future Research

This current study initiated a starting point for an area of research on the implementation of the professional development in mathematics with a specialist training model. Other subject areas such as science, language arts and social studies are equally important as mathematics and deserve to be investigated. Further research could build on the findings of this study by analyzing test scores to make a strong link between teacher acquisition and transfer of knowledge and student learning.

Longitudinal studies could allow for the investigation on how the students continue their mathematical journey into high schools. Many students become anxious and lack interest in

mathematics when they reach high school. Following these students could determine if students who are nurtured on their mathematical journey are successful.

Further research is needed to determine if professional development has longevity. Too often professional development seeks to empower teachers and substantial resources are used to pilot the enactment for a limited time. Further research can provide insight to the field on how to strengthen the efforts of meaningful and well organized professional development.

This case study was conducted to determine the impact of the implementation of the Primary Specialist Teacher Model for mathematics in four primary schools in Jamaica. The findings provided insight about the mathematics pilot project in multiple schools that can inform the program managers, the Ministry of Education, school leaders, teachers, and mathematics coaches. Transformative learning theory is critical, and this study supports previous findings. The study successfully investigated teachers' perceptions of the mathematics pilot project that can be used to make informed decisions about professional development in the future. The instructional practices employed in the four schools paralleled the professional development program. The findings throughout the study revealed that the professional development was successfully implemented resulting in teacher developing their repertoire of teaching skills that influenced student learning outcomes.

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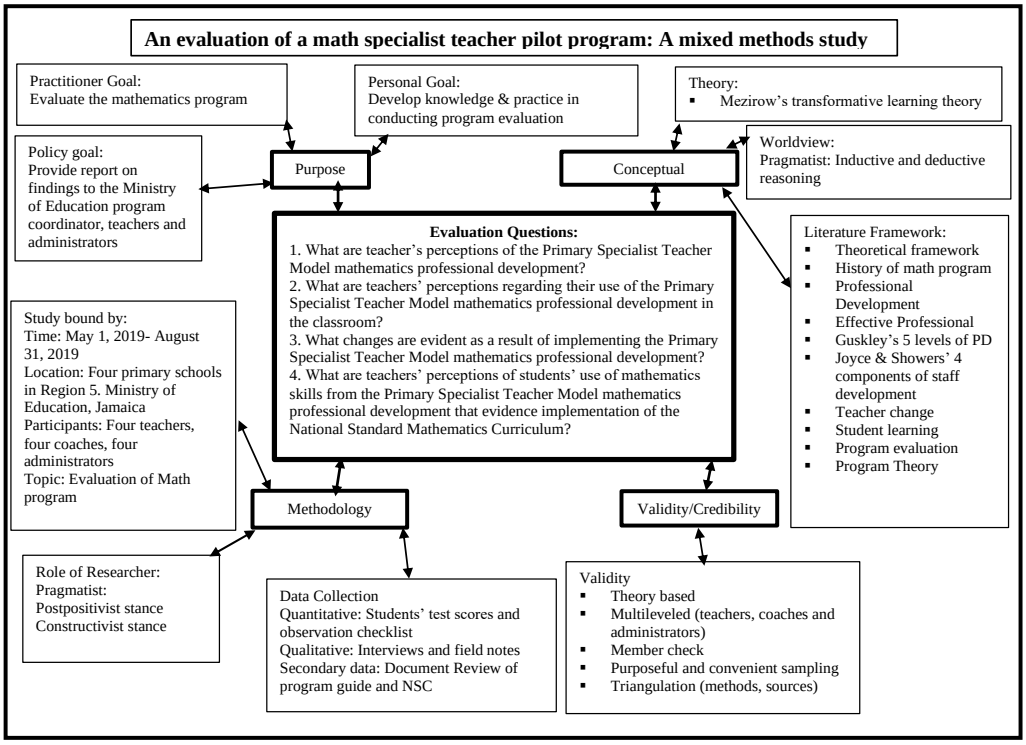
Appendix A

Worldview Matrix

Researcher's Worldview	**Constructivism**	**Post positivism**	**Pragmatism**
Epistemology: What is knowledge? What is shared reality between the researcher and what is researched?	Closeness: Researcher visits site over time, establishes relationships and collects data in the form of interviews and field notes as she engages participants to gain understanding of teachers' perspectives. Researcher and participants co-construct knowledge.	Observation checklist protocol will be used to collect data from three grade 6 teachers. Researcher collects secondary data that are value free (test scores).	Etic (partial outsider view) during part of observations. Emic (insider) Researcher and participants recognize their views are valuable in this program evaluation.
Axiology: What is the role of values in investigating curriculum implementation?	Researcher and participants recognize their own bias and negotiate meaning when making interpretations of the topic.	From a post positivist perspective, the researcher will analyze test scores data carefully to present accurate information value free	Multiple stances: Value constructivist and transformative perspectives to integrate in the evaluation conclusions.
Methodology: What process of research is used in this investigation?	Inductive approach: Researcher uses participants' views to build patterns, themes and concepts that lead to a theory about the topic.	Deductive approach: students' scores and observational checklist done, both data will be analyzed to confirm or disconfirm theory	Qualitative and Quantitative data Approach: Researcher collects both qualitative and quantitative data and analyzes data in the best way employing thematic coding and member check to present teachers' perspectives Triangulation of data

Appendix B

Concept Map



Appendix C

Observation Checklist Protocol

Using a scale of 1- Not At All, 2-To A Small Extent, 3-To A Moderate Extent, 4-To A Large Extent, 5-To A Great Extent

	Not At All	**To small A Extent**	**To A Moderate Extent**	**To Large Extent**	**To A Great Extent**
Planning					
1. Design of lesson reflects careful planning and organization.					
2. Integrated approach evident.					
Facilitation of Learning					
3. Teacher acts as a facilitator					
4. A variety of techniques is used to facilitate/collaboration.					
5. Time provided to complete lesson is managed effectively.					
6. Lesson accommodates different learning styles/multiple intelligences and learning abilities.					
7. Lesson accommodates students' prior knowledge and experiences.					
8. Strategies used facilitate learning.					
9. Instructional strategies appropriate.					
10. Instructional strategies effectively used.					
11. Instructional strategies varied.					
Instructional Materials					
12. Teacher uses instructional materials effectively.					
13. Students use learning materials effectively.					
Assessment Approach					
14. Students are assessed at different stages of lesson.					
15. Useful and continuous feedback is evident.					

16. A variety of strategies is used to measure students' progress.					
17. An assessment plan is used to guide assessment activities.					
18. Teacher's instructional decisions are informed by assessment data.					
Interactions					
19. Classroom atmosphere encourages student participation.					
20. Students actively participate in classroom activities.					
21. Lesson design encourages collaborative learning approach.					
22. Classroom is a resource rich environment.					
23. The classroom is arranged to facilitate collaborative/team learning.					
Physical Environment					
24. Physical environment supports student centered learning.					
25. Information Communication Technology (ICT) infrastructure is adequate.					

Note. Adapted from "System for Monitoring Activities, Resources and Teaching (SMART): Lesson Observation Protocol for Principals and Middle Managers" by Ministry of Education, Youth and Information, p. 4. Copyright 2017 by PMEU/PDD/MOE.

Appendix D

Structured Interview Protocol for Teachers

1. How do you describe the Primary Mathematics Specialist Teacher professional development? What does it mean to you?

2. How was this professional development different from the previous mathematics professional development?

3. What about the Primary Mathematics Specialist Teacher professional development would you continue to do and why? What would you change and why?

4. How have your knowledge been enhanced by the Primary Mathematics Specialist Teacher professional development?

5. In what way has the Primary Mathematics Specialist Teacher professional development influenced your teaching practice?

6. What do think Primary Mathematics Specialist Teacher should be included in your next Primary Mathematics Specialist Teacher professional development?

7. In what way was the primary mathematics specialist teacher professional development hindered or facilitated by the school?

8. How do you describe the support for the implementation of the Primary Mathematics Specialist Teacher professional development?

9. How has the scheduling influenced the effectiveness of the Primary Mathematics Specialist Teacher professional development?

10. What instructional strategies have you implemented consistently as a result of the Primary Mathematics Specialist Teacher professional development?

11. What is your perception of the Primary Mathematics Specialist Teacher professional development as a way of strengthening the implementation of the National Standard Curriculum?

12. How do you think the Primary Mathematics Specialist Teacher professional development affected student learning?

13. Is there anything you would like to add that you view as important to understanding the Primary Mathematics Specialist Teacher professional development?

Appendix E

Semi-Structured Interview Protocol for Mathematics Coaches

1.How do teachers describe their experience the Primary Mathematics Specialist Teacher professional development?

2. What is different in the Primary Mathematics Specialist Teacher professional development from previous approach to teaching mathematics?

3. In what way has the Primary Mathematics Specialist Teacher professional development influenced teachers' instructional practice?

4. What do you think should be included in the next Primary Mathematics Specialist Teacher professional development?

5. In what way has the implementation of the Primary Mathematics Specialist Teacher professional development been hindered or facilitated by the school?

6. In what way does your role influence the implementation of the Primary Mathematics Specialist Teacher professional development?

7. How do you describe the support for the implementation of the Primary Mathematics Specialist Teacher professional development?

8. What instructional strategies have teachers implemented as a result of the Primary Mathematics Specialist Teacher professional development?

9. What is your perception of the Primary Mathematics Specialist Teacher professional development in strengthening the implementation of the National Standard Curriculum?

10. How do you think the Primary Mathematics Specialist Teacher professional development affected student learning?

11. Is there anything you would like to add that you view as important to understanding the piloting of the Primary Mathematics Specialist Teacher professional development?

Appendix F

Structured Interview Protocol for School Administrators

1.How would you describe the Primary Mathematics Specialist Teacher professional development?

3. In what way has the Primary Mathematics Specialist Teacher professional development influenced teachers' instructional practice?

4. In what way should the Primary Mathematics Specialist Teacher professional development be improved to meet the need of teachers for a more effective implementation?

5. In what way has the implementation of the Primary Mathematics Specialist Teacher professional development hindered or facilitated by the school?

6. In what way does your role influence the implementation of the implementation of the Primary Mathematics Specialist Teacher professional development?

7. How do you describe the support for the implementation of the Primary Mathematics Specialist Teacher professional development?

8. What instructional strategies have teachers implemented as a result of the Primary Mathematics Specialist Teacher professional development?

9. What is your perception of the Primary Mathematics Specialist Teacher professional development to strengthening the implementation of the National Standard Curriculum?

10. How do you think the Primary Mathematics Specialist Teacher professional development affected student learning?

11. Is there anything you would like to add that you view as important to understanding the piloting of the Primary Mathematics Specialist Teacher professional development?