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Understanding self-directed professional development in mathematics for elementary teachers: A phenomenographical study

Chloe D. Weir
The University of Western Ontario

Supervisor
Dr. Immaculate Namukasa
The University of Western Ontario

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Abstract

This qualitative research focused on elementary teachers' conceptions of self-directed professional development. Self-directed professional development is professional development that is internally motivated and arises from the teacher's own initiative (Eekelen, Vermunt, & Boshuizen, 2006; Mushayikwa & Lubben, 2009). The central question that framed this research is: How do elementary teachers perceive, engage in, and understand the role of self-directed professional development in elementary mathematics education? Given that elementary teachers should nurture students' interests and abilities in mathematics, it is important to understand how they foster their own professional growth through self-directed professional development in mathematics education.

Teachers' conceptions of self-directed professional development were analyzed through the lens of phenomenography. The goal of phenomenographic research is to describe various ways in which people experience a phenomenon (Limberg, 2008; Marton, 1981; Marton & Pong, 2005; Trigwell, 2006). Mezirow's (1991) theory of transformative learning and Knowles' (1984) theory of andragogy are the theoretical frameworks on which the teacher-participants' experiences of self-directed professional development were interpreted. The iterative process of reading and coding data as described by Chamaz (2008) was incorporated in the phenomenographic data analysis. Teacher-participants' conceptions of self-directed professional development resulted in an outcome space of five categories of description.

Findings suggest that elementary teacher-participants are passionate about mathematics teaching and their professional growth through self-directed professional development. Teacher-participants used a variety of formal and informal activities to facilitate their own learning in mathematics education. Teacher-participants' engagement with self-directed professional development resulted in transformational thinking and practices in their mathematics education. Elementary teacher-participants, whether novice or experienced, engaged in professional learning activities aimed at providing meaningful teaching and learning experiences for themselves and their students. Self-directed professional development provided teacher-participants with autonomous, empowering experiences as they made professional judgments regarding the time, context, and content of their professional learning experiences.

Key Words: andragogy, categories of description, outcome space, phenomenography, self-directed professional development, phenomenography, transformative learning.

Dedication

I dedicate this work to my Papa, Kenneth Weir and my Mama, Iris Weir, who sent my siblings and me to school every day. Their constant love, encouragement and support served to inspire us to focus on our schooling. This study is also dedicated to my nephew Ikenna, who taught me the meaning of true love. I hope Ikenna will benefit from teachers who invest in their learning, and that of their students. Auntie loves you dearly Ikenna.

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Last, but by no means least, I want to thank God for sustaining me on this interesting journey.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms

ANT	**:**	Actor Network Theory
AQ	**:**	Additional Qualification
Bed	**:**	Bachelor of Education Degree
CMESG	**:**	Canadian Mathematics Education Study Group
CPD	**:**	Continuing Professional Development
ESL	**:**	English as a Second Language
ETFO	**:**	Elementary Teachers' Federation of Ontario
FGI	**:**	Focus Group Interview
MOE	**:**	Ministry of Education
MPEd	**:**	Master of Professional Education
OAME	**:**	Ontario Association for Mathematics Education
OCT	**:**	Ontario College of Teachers
OECD	**:**	Organization for Economic Cooperation and Development
ORMS	**:**	Ontario Renewed Mathematics Strategy
PD	**:**	Professional Development

PhD	**:**	Doctor of Philosophy
PLC	**:**	Professional Learning Community
PLN	**:**	Professional Learning Network
RQ1	**:**	Research Question 1
RQ2	**:**	Research Question 2
RQ3	**:**	Research Question 3
RQ4	**:**	Research Question 4
RQ5	**:**	Research Question 5
SDL	**:**	Self-Directed Learning
STEM	**:**	Science, Technology, Engineering, and Mathematics
TLLP	**:**	Teacher Leadership and Learning Program

Chapter 1
Research Introduction

1.0 Introduction: My Story

A pivotal moment in my teaching career of over 15 years occurred one sunny Wednesday morning while I was teaching mathematics to fourth graders. We were learning about long division when an interesting situation unfolded. Long division is an algorithm that repeats the steps of division, multiplication, and subtraction. When I asked the students if they understood my explanation, from a class of 24 only one said he understood the concept. The student, who I will call John, then offered to explain the concept to his group. After his explanation, the other three students in his group said they understood. Upon hearing this, five other groups asked John to explain the concept to them and he did.

I watched and monitored the activities of the other groups, who were displaying competencies with the concept being taught. When John was through explaining division to the groups, I asked each student independently to explain what he/she understood about the topic. To my utter amazement, all the students said that they grasped it. Furthermore, they demonstrated their understanding by independently solving three problems. By this time, I was thinking to myself that John must have been explaining the concept differently than I had done.

While learning the concept of long division, the relevant vocabulary (e.g., dividend, divisor, and quotient) was introduced with what I considered meaningful

examples and explanations. At my request, John went to the chalkboard to demonstrate and explain the procedure to the entire class. His explanation of the concept was quite like mine. While demonstrating how to divide 168 by 4, John also used words like "remember to subtract" and "place the quotient here." When given a quiz at the end of the lesson to test their individual understanding, all 24 students demonstrated competencies, scoring 80% and above. In addition to high scores, students were talking about the mathematics procedure in ways that showed that they understood it. Students were explaining the processes involved in solving problems related to long division. I was in stunned disbelief, as I could not understand what I had witnessed in my classroom that morning.

This experience resulted in a change in my thinking regarding my teaching practices. Until then, I thought I was providing carefully constructed demonstrations and examples when explaining new concepts to my students. John proved me wrong. After further thought, the following questions came to the fore: How can I improve on my teaching strategies in mathematics? What can I do to ensure that my students excel in mathematics? How can I incorporate peer teaching in my Grade 4 classroom to facilitate learning? These questions and more filled my daily thoughts as I reflected on my role as an elementary teacher entrusted with making learning meaningful to students every year.

Professional development (PD) and reflective practice took on a new meaning as I realized that I needed to change the strategies and techniques used in my teaching practice. Professional development of teachers refers to the learning activities initiated by educational institutions and by teachers themselves. Professional learning activities

can be done individually and with others. I began to find innovative ways to engage my students in learning mathematics not only to elicit learning of procedures, but also to develop in them deep interest, a camaraderie in learning, and an understanding that mathematics learning is applicable to everyday situations. It was a journey that led me to conclude that teachers are powerful agents in education, as they can effect change and foster meaningful learning for students. After reading teacher magazines, researching books on mathematics education, and having discussions with more experienced teachers and colleagues, I formed a plan to make my mathematics lessons more engaging. I experimented with cooperative learning techniques. Cooperative learning refers to classroom techniques in which students work on learning activities in small groups (Slavin, 1980). Students' interest and performance in mathematics, as seen in subsequent lessons, appeared to improve when I used cooperative learning techniques.

In the jurisdiction where I worked, I took advantage of the opportunities provided for teacher learning and professional development at the grade, departmental, and district levels, and by the Ministry of Education (MOE). Notwithstanding the professional development activities in which I participated, what most affected my learning, as a teacher and my subsequent classroom practice were my personal reflection on said practices and the concrete actions I undertook to enhance my professional growth.

My personal reflection was enhanced by journaling, as I chronicled the daily occurrences in my classroom and highlighted the practices that elicited positive student responses and those that elicited negative student responses. The journaling was augmented with the readings from my students' journals, as three times per week they

wrote about the activities done in the classroom that they liked or disliked and the application of what they learned. Students commented on my teaching as well and, in some instances, identified other concepts they wanted to learn.

Looking back, I can say that my interest in professional development as a classroom teacher resulted from my reflective practice, which was instrumental in determining the changes necessary in my pedagogical practices. The cooperative learning techniques proposed by Johnson and Johnson (1999) that I adapted in my mathematics lessons provided relevant and engaging learning opportunities for my students. In addition to their improvement in mathematics, students increasingly expressed confidence in their ability to apply mathematical concepts, not only in mathematics lessons but also in other subjects. This experience was empowering for me as a classroom teacher. I became aware of the impact my decisions to teach using different techniques and strategies had on students' learning and their perception of themselves as high achievers in mathematics.

I was motivated to become more involved in professional development activities at the school because of that experience in my classroom. A study group was formed at school where teachers reflected on their practice, demonstrated, and discussed how to introduce mathematical concepts to students in innovative ways. The study group was beneficial as it fostered the development of a community of teacher learners whose goal was to make learning mathematics an enriching experience for the students. My personal and professional growth as a teacher resulted from investing in my own learning and adapting my teaching strategies to improve my practice.

The occurrence in my classroom several years ago was a catalyst for change in my approach to professional development. After this occurrence, professional development took on new meaning, as I realized that I needed to make changes to my classroom practice. Regarding the specific incident in my classroom, I noted that whereas there was a deficiency in students' understanding of mathematical concepts specifically related to long division, after listening to their classmate teach, students appeared to have gained a deeper understanding of the concept. The use of cooperative learning strategies further improved students' learning and their perceptions of themselves as mathematics learners. Students' problem-solving skills improved as I introduced new teaching strategies in mathematics lessons and provided interesting ways to engage the students in meaningful learning activities.

I saw camaraderie develop when students are learning together in small groups, listening to each other, talking about mathematics concepts, and working collaboratively on the same task. It is also likely that the novelty of having their classmate lead the teaching, served to motivate students and aided understanding of the concept they were learning. From my observations, students were clearly working together in small groups and supporting each other in the learning process by explaining and demonstrating the concept. I developed an awareness that teachers need to change their teaching strategies from, for example, the strategy of teacher talks and the students listen, to strategies where they encourage more student interaction. In addition, I learned that at times well-intended teaching techniques may instead inhibit student learning. Most importantly, I learned that as a teacher, the choices I made when planning the lesson, during the lesson,

and after the lesson can have a far-reaching impact on students' understanding and learning.

I chose to be involved in learning that was not only beneficial to me, but geared towards student learning. I decided to be more engaged in professional development activities, especially in self-directed professional development. Self-directed professional development is professional development that arises from the teacher's initiative (Mushayikwa & Lubben, 2009). The self-directed professional development that I engaged in allowed me to foster my own learning, in terms of the content, teaching practices and learning resources that were now available to me. I began to attend professional development seminars with renewed vision as I tried to improve my teaching skills in mathematics education. I started to be more alert to my students' needs. I also read books on innovative teaching techniques, in addition to engaging my colleagues in discussions about the teaching practices that were effective in their classrooms.

Self-directed professional development led me on a learning path that allowed me to explore diverse ways of teaching and learning. The professional judgments that I made reflected an understanding of my learning needs and the needs of my students. My experiences have taught me that teacher professional development can be complex and often impacted by several factors, including school culture, learning needs, interests, and one's commitment to professional growth. The nexus of this experience was that my reflection on practice resulted in more student-centered pedagogy in the context of my practice, and I had the autonomy to choose relevant and interesting learning activities that fulfilled specific needs. Reflective practices that I engaged resulted in problem solving

and continued learning (Schön, 1987). Schön stated that reflection plays a key role as individuals focus on their experiences that impacts their learning. The experience in my classroom several years ago led me to initiate and conduct action research, which fostered an appreciation for mathematics learning and improved students' interest and performance in mathematics.

1.1 Situating My Professional Development

Teachers' engagement in continuous learning is one way of facilitating professional development to improve one's pedagogy. Continuous learning according to Maurer and Weiss (2010) involves four competences (a) developmental orientation (b) ability to learn things readily (c) inner work standards to do their best and (d) recognition of one's strengths and weaknesses. As an educator for over 15 years at the K-9 level, the situation that transpired in my classroom several years ago, while teaching long division, led me to a different understanding of how professional development can result in improved learning opportunities for students and teachers. This experience also motivated me to be engaged in continuous learning activities. I experienced the competences identified by Maurer & Weiss (2010 while undergoing my transition to a deeper level of professional development. My research on self-directed professional development was motivated by the change in my thinking about what professional development means. It is within my personal narrative on the challenge that faced me, and my subsequent engagement in professional development, that I situate this study.

1.2 Research Context and Rationale

A plethora of arguments exists highlighting the significance of ongoing professional development for teachers. Ongoing professional development in mathematics education, specifically for elementary teachers, is critical for many reasons. In synthesizing over 100 articles written between 1985 and 2008 on the professional learning practices of mathematics teachers, Goldsmith, Doerr, and Lewis (2014) asserted that mathematics teachers continue to learn over the course of their career and that students' learning is largely influenced by teachers' current mathematical thinking and related pedagogical thinking. Teachers should continue to develop their mathematical thinking and to remain current to meet the ever-changing needs of the students they teach.

After Bubb and Earley (2007), I consider teachers as professionals. An identifying mark of a professional is an individual's ability to be continuously engaged in learning throughout one's career (Bubb & Earley). Teachers who are actively involved in self-directed professional development activities set their own learning program by seeking, designing, and engaging in learning activities, and by evaluating their own learning outcomes (Cummings, 2011). I sought to understand how elementary mathematics teachers, who nurture young students' interest in mathematics, foster their professional development through self-directed activities. Elementary teachers, like all teachers, need to be knowledgeable and aware of new teaching practices and technologies to ground students' interest and abilities**.** Preparing children and youth with capacity to manipulate, calculate, assess, reason, analyze, hypothesize, and evaluate enhances their

functionality in the science, technology, engineering, and mathematics (STEM) workforce. Furthermore, this preparation provides children and youth with the skills necessary for full participation in modern society and builds a strong base of future mathematics teachers to teach in an era of changing curriculum (Jordan, Glutting, & Ramineni, 2010). The elementary mathematics teacher facilitates the development of skills that are the building blocks for learning maths concepts in higher grades. Students' learning is built on the foundational concepts as they move to higher levels of schooling.

My study on self-directed professional development was carried out in Ontario, Canada, with elementary teacher-participants. Ontario's teachers participate in professional development activities and the MOE mandates some of these activities. In addition, some teachers hold membership in professional organizations such as the *Ontario Association for Mathematics Education (OAME)* and the *Canadian Mathematics Education Study Group* (CMESG), where they engage in professional development activities that promote teacher learning in both formal and informal settings. It was a desire to understand elementary mathematics teachers' conceptions of self-directed professional development in the Canadian context that I carried out this study in Ontario, where the government had announced a plan to fund mathematics education specifically to improve mathematics teaching and learning.

In 2016, the MOE earmarked $60 million through the Ontario Renewed Mathematics Strategy (ORMS) to help improve student achievement in mathematics. This funding will support mathematics teaching and learning from Kindergarten to Grade 12 and includes increased daily mathematics learning time as well as the provision of

increased professional learning opportunities for elementary teachers (Ministry of Education Ontario, 2016). The goal of the MOE is that at least 75% of students meet the provincial standard. The MOE strategy to provide increased professional learning opportunities for elementary teachers is laudable in an era when mathematics learning is critical for many reasons. To effectively prepare students, more teachers must access professional development opportunities, as they are central to education (Guskey, 2002).

It is inevitable in an era filled with educational and curriculum renewals, many of which are based on research and evidence, that teacher professional development will be necessary (Jarvis, 2006). Day and Sachs (2004) agreed that there is a fundamental need for teachers to be engaged in professional development so that they will have the skills and knowledge to provide students with learning experiences that are both relevant and contextual to their needs. Furthermore, Lappan (2000) argued that professional growth and development of the teacher is so important that it should be supported throughout their career. Teacher professional development that is a lifelong process provides teachers with tools that enable them to engage students in activities that promote learning.

Hennessey, Higley, and Chesnut (2012) asserted that there is monumental importance for mathematics outside of the classroom. To fulfill this need, students should not only learn mathematics, but also have a deep understanding of mathematics taught in the classroom. Mathematics education is relevant and elementary teachers should be equipped with mathematical tools to engage young learners (Kajander, 2010). The ability to think is essential for achievement in science, engineering, and other areas such as the arts. Canada is a major player in both the economic and the political world; it

is imperative that Canadian students are competent and efficient with mathematical literacy skills**.**

Teachers play a critical role in education and their knowledge of the subject matter is crucial for improvement in the quality of instruction (Hill & Ball, 2004). The drive to help students perform in mathematics is inclusive of girls, English language learners, students with special needs, and students in urban areas. I will show in a later chapter that Canadian schools are diverse in student population. There are reasons other than competing in international tests for schools, provinces, and the MOE to put in place structures that focus on mathematics education. These reasons include improving students' problem-solving skills, extending students' mathematical knowledge, and encouraging multiple approaches to the teaching and learning of mathematics. Hence, the rationale for this study is that it is important to understand how elementary teachers perceive, engage in, and explain self-directed professional development in mathematics education.

1.2.1 Teacher roles.

Teaching practices, teacher education, and teacher characteristics are areas of concern in education. It is sometimes incorrectly perceived that students' grades are synonymous with teacher performance, whereas there may be several factors that could be considered, as teaching and education are complex matters. One societal goal is that teachers be transformational in their teaching, actively engage students in meaningful learning experiences, and provide students with the requisite skills and knowledge to function effectively in this twenty-first century (Ball, 1993; Bight, 2012; Joyce &

Calhoun, 2010). Journals such as *Professional Development in Education,* and *Teacher Development and Journal of Education Research* have been devoted to the topic of professional development for several years. They provide up-to-date information on the various models of professional development and research data on professional development in education.

The continuous professional development of the teacher is important in the teaching of mathematics and all other subjects. Owen (2014) stated that re-skilling the teacher using quality ongoing professional development is not only essential for the teacher but also important in improving student outcomes. In addition, Owen (2014) stipulated that effective professional development in which teachers update their skills and knowledge, is not only important for the changing educational scene, but also has political and economic ramifications. Kajander (2010) asserted teachers need support in their own mathematical development, so that they can better help their students understand mathematical concepts.

Professional development occurs in various ways. These include attending workshops, seminars, webinars, and teacher study groups; completing Additional Qualification (AQ) courses and pursuing graduate studies. Professional development may also take the form of professional learning communities (PLCs) in schools where teachers plan together and execute teaching strategies. The advent of the Internet has opened new ways of communicating and learning. Some teachers are using social media tools like Facebook, Twitter, YouTube, Wikis, and Blogs to enhance their professional learning (Rampai, 2015).

The past two decades have helped to redefine teachers' role in the society as the changes associated with globalization, growing economies, migration, and technological advances have influenced education. Schools prepare students to fulfill societal roles and increasingly this role is magnified as society moves from an industrialized context to a technologically advanced state. Within this context, schooling requires that teachers have expertise with innovative technologies along with diverse instructional techniques to meet the equally diverse and challenging needs of students. Jarvis (2010) contended that the professional development of mathematics educators must be recognized as an important link in teacher practice. Darling-Hammond and Bransford (2005) confirmed that understanding how professional learning occurs is central to mathematics education as it helps teachers in preparing and providing effective teaching and learning resources that are beneficial to students.

1.3 Research Focus

My research draws upon the methodological framework of phenomenography, focusing on self-directed professional development in elementary mathematics education. Self-directed professional development is professional development that is teacher-initiated, teacher-driven, and focuses on teachers' needs (Mushayikwa & Lubben, 2009). For the purposes of this research, self-directed professional development may include any professional or learning activity that teachers engage in, whether individually or collectively, outside of what is mandated by the MOE, provinces, schools, or local school boards.

1.4 Overarching Research Question

The overarching research question guiding this study is: How do elementary teachers perceive, engage in, and understand the role of self-directed professional development in elementary mathematics education? This question seeks to explore how elementary teachers understand self-directed professional development in teaching.

In this study, the ability to perceive is an act done after one has experienced a phenomenon. Merleau-Ponty (1962) in his seminal work *Phenomenology of Perception* described perception as an act done through one's imagination when one's thinking is fastened upon this mental experience. Teacher-participants described how they perceived and experienced self-directed professional development. To describe their engagement in self-directed professional development, teacher-participants reported on the activities in which they had been active participants. In explaining their understanding of self-directed professional development, teacher-participants attributed meaning to their experiences.

1.5 Specific Questions

The specific questions that guided this study on self-directed professional development in elementary mathematics education are:

1. What is the nature of the self-directed professional development activities in which teachers are engaged and how do teachers experience self-directed professional development in their practice?
2. What are the factors and teacher characteristics, if any, that lead to self-directed professional development among elementary mathematics teachers?

3. What are the conditions, if any that support teachers' involvement in self-directed professional development?
4. To what extent is self-directed professional development transformational?
5. What are the variations of experience reported by teachers who engage in self-directed professional development?

These questions provided a lens for understanding teacher-participants' views about self-directed professional development and the variations in their understanding of this phenomenon.

1.6 Goals of the Study

The goals of this research were three-fold. The first goal was to better understand how elementary teachers view self-directed professional development in mathematics education. There is growing consensus in education circles that professional development of teachers is at the core of educational reform and improvement in classroom instruction (Elmore & Burney, 1999; Owens, 2014). Given that teacher professional development is at the core of educational reform and classroom practice, there is a need to study how teachers prepare themselves to fulfill their roles in the elementary classroom. The role of the elementary school mathematics teacher in Ontario includes helping students develop mathematical processing skills like problem solving, reasoning, connecting, and representing as outlined in the *Ontario Curriculum Grades 1-8* (2005).

Secondly, there is much research on professional development (Atay, 2007; Borko, 2004; Loucks-Horsley & Matsumato, 1999; Lunenberg & Wilemse, 2006; Pitsoe & Malia, 2012), but there is a paucity of literature on self-directed professional development. This research adds to the literature on self-directed professional development and continue the conversation on teacher professional development. This study will further inform investigations in professional development and self-directed professional development in other areas of education.

The third goal of this study was to seek a better understanding of how teachers can be supported in their self-directed professional development activities throughout their careers. Teachers' pedagogical content knowledge in mathematics education provide them with the knowledge and skills necessary for teaching mathematics (Piccolo, 2008., Shulman, 1987). Barnett and Hodson (2001) agree that pedagogical content knowledge includes preparation of lessons, setting goals, organizing lessons cohesively and allocating sufficient time for treating significant concepts in the subject. Understanding teachers' ability to engage in the content supporting their professional development through self-directed professional provides educators with insights on the supports needed for professional development.

1.7 Methodological Approach: Phenomenography

The methodology that grounded this research on self-directed professional development was phenomenography. Phenomenography is a research methodology that examines the different ways in which people experience, interpret, understand, apprehend, perceive, or conceptualize various aspects of reality (Marton, 1981). People

experience a phenomenon in only a limited number of qualitatively different ways (Marton, 1994). In phenomenography, the focus is on the reflected experiences of the individual (Greasley & Ashworth, 2007). I chose this methodological approach because it informed my study and provided a basis for understanding how teachers perceive, engage in and understand self-directed professional development.

1.8 Theoretical Framework: Mezirow's Theory of Transformative Learning and Knowles' Andragogy

Mezirow's (1994) theory of transformative learning and Knowles' (1970) theory framework of adult learning, andragogy, provided the lens through which I researched how teachers perceived, engaged in and understand self-directed their experiences with self-directed professional development. Mezirow (1994) defined transformative learning as the social process of construing and appropriating a new or revised interpretation of the meaning of one's experience as a guide to action. I chose Mezirow's theory of transformative learning because of its underlying notion of adults making choices and facilitating changes in their circumstances. I am interested in finding out the ways in which teacher-participants' experiences with self-directed professional development resulted in transformation in their professional lives and their practice.

Andragogy refers to adult learning in which learners are responsible and have control over what they learn, producing independent and capable individuals (Knowles, 1970). Andragogy was selected for my research because of its focus on learning.

1.9 Key Definitions

Outlined below are the definitions of the key concepts used in this investigation on self-directed professional development among elementary teachers in mathematics education.

1.9.1 Professional development.

Professional development refers to both professional learning initiated by institutions and that by individuals. Professional development in this study includes activities that are mandated by departments, institutions, school boards and the ministry of education. It also includes all activities done to enhance teacher learning individually or collectively to promote and enhance teacher growth and learning including, but not limited to, additional qualification courses offered by colleges and universities, conferences, workshops, seminars, webinars, collaborative learning communities and the use of social media.

1.9.2 Self-directed professional development.

Self-directed professional development according to Mushayikwa and Lubben (2009) refers to professional development that arises from the teacher's initiative. Self-directed professional development may take several formats. It includes collaborative efforts with other teachers whether or not they are in the same school or school district.

1.9.3 Phenomenography.

Phenomenography is a research methodology that examines the different ways in which people experience, interpret, understand, apprehend, perceive, or conceptualize

various aspects of reality (Marton, 1981). Phenomenography focuses on reflected experience, meaning that the emphasis is on the experience described (Greasley & Ashworth, 2007).

1.9.4 Conception.

Conceptions are "different ways of understanding" (Marton & Pong, 2005, p. 335). They are typically represented in the forms of categories of description. Conceptions in this study refer to one's understanding.

1.9.5 Categories of description.

The categories of description are the researcher's abstractions of the different ways of understanding that the researcher has identified. They refer to a collective level and describe the different ways the phenomenon can be understood (Larrson & Holmstrom, 2009).

1.9.6 Mezirow's theory of transformative learning.

Mezirow (1994) defined transformative learning as "the social process of construing and appropriating a new or revised interpretation of the meaning of one's experience as a guide to action" (p. 222). Learning is the "process of using prior interpretation to construe a new or revised interpretation of the meaning of one's experience as a guide to future action" (Mezirow, 2000, p. 5).

1.10 Chapter Summary

In this first chapter, I have provided an overview of my study on self-directed professional development of elementary mathematics teachers, which I conducted in Ontario, Canada. My goal was to understand how teacher-participants perceive, engage in, and understand self-directed professional development. Through the methodological lens of phenomenography, the theoretical frameworks of Mezirow's transformative learning theory and Knowles's andragogy, I planned to explore the nuances of self-directed professional development. This study provides insight on how elementary teachers perceive, engage in, and understand self-directed professional development and its impact on their professional practice. The rationale for this study is that ongoing professional development is necessary for most elementary mathematics teachers who meet students in their early years, when an interest in mathematics is fostered and encouraged. In addition, many teachers' need to continue to learn over their career and for their mathematical thinking and pedagogy to remain current to meet students' learning needs.

Chapter 2

Literature Review

2.0 Introduction

The purpose of this chapter is to review the scholarly literature that informs this research on self-directed professional development in elementary mathematics education. I conducted a review on self-directed professional development to situate the study in literature relevant to self-directed professional development in mathematics education. I searched the following digital education databases: CBCA Education, ProQuest, JSTOR, PsycINFO, Google Scholar, and ERIC. I searched for variants of the phrase *professional development* and *learning of teachers in education*, after which I further selected to review articles on professional development of teachers in mathematics education. Articles on self-directed professional development and learning in mathematics education were of interest.

The literature is categorized according to the nature of teacher professional development and changes in mathematics education, changes in schooling, and the changes in society that make professional development of teachers necessary. I also added to this chapter, studies in mathematics education that utilized phenomenography, which I searched for and reviewed when studying the methodology for this research. The first two sections of the literature review are general studies about teacher lifelong learning and teacher professional development in the context of culturally responsible teaching. Following this, I reviewed literature on the different ways in which teachers engage in professional development, which includes self-directed professional

development and self-directed learning (SDL). Next, I focused on mathematics education, addressing twenty-first century skills and professional development in this context. This is followed by a section on professional development and technology, which addresses the changes that make professional development necessary.

The chapter ends with a section on studies in mathematics education that used phenomenography method and a final section on the implications of self-directed professional development for teachers.

2.1 Continuous Professional Development

Villegas-Reimers (2003) stated that professional development should be considered a long- term dynamic process, beginning with the initial teacher education programme and ending at retirement. Certain researchers have talked about the professional development process as a lifelong learning process (Bubb & Earley, 2007; McMahon, 1997; Norman, 2016; Villegas-Reimers, 2003; Webster-Wright, 2006). One of the identifying marks of a professional is to be engaged in continuous learning throughout one's career. To be an excellent teacher one must invest in oneself (Bubb & Earley, 2007; Norman, 2016). The literature on professional learning identifies teacher education as a lifelong collaborative learning process. Teachers need to keep pace with continuously emerging knowledge, renewed and revised curriculum, new teaching and learning resources, and new teaching techniques. Through continued learning teachers, as individuals and with colleagues, foster their professional growth to provide meaningful learning experiences for students (Smaller, 2005; Speck & Knipe, 2001). Teachers continuously engage in professional development activities to develop their teaching

skills and abilities (pedagogy) as well as their knowledge of the content they teach. McMahon (1997) added that since schooling is a lifelong process, teachers do return to the classroom periodically to upgrade their skills and knowledge. On the other hand, Bolam (1993) referred to continuing professional development (CPD) as professional development activity that teachers engage in to enhance their knowledge and skills with a view to improving both the quality of the teaching and the learning process. Guskey (2000) asserted that teachers who are engaged in CPD are building their knowledge base and keeping abreast of new technologies throughout their teaching career. Beaver (2009) added that it is now widely accepted that teachers need CPD, inclusive of training on educational standards and relevant strategies for the classroom. Teachers need professional development on changes in content standards and curriculum as well as on other changes in society that affect schools in general.

Recognizing that teacher professional development should be continuous, Day (1999) opined that as teachers engage in ongoing learning opportunities and upgrade their skills throughout their teaching career, they are reviewing, renewing, and extending their commitment as change agents to the moral purposes of teaching. Tang and Choi (2009) asserted that the development of the teacher is situated in a biographical context since teachers have different professional needs, some of which develop over time to create their professional selves. Teachers have needs at the beginning of their careers, while other needs develop during their career as their knowledge and experiences grow, resulting in ongoing learning. Hargreaves and Fullan (1992) stated that the development of teachers occurs at different points in their lives and the path to professional development is different for each teacher.

Over the last two decades, there has been extensive research on teacher professional development and teacher change (Clarke & Hollingsworth, 2002; Garet, Porter, Birman, DeSimone, & Yoon, 2001; Guskey, 1986, 2002, 2003; Lampert & Ball, 1998; Porter, Birman, Garet, Desimone, & Yoon, 2004; Raymond, 1997; Tatto, 2014). Teacher professional development can be an empowering process through which teachers can take charge of advancing educational practice and reinforce existing professional knowledge (Hannay, Wideman, & Seller, 2006). Lifelong learning is embedded in the teaching profession and teachers' knowledge and experiences accumulated over time can help to support schooling and the process of knowledge construction.

2.2 Teacher Professional Development: Culturally Responsive Teaching

McAllister and Irvine (2002) maintained that to accommodate today's divergent student population, efforts should be made to learn about the different cultures and ways of life so that teachers can use this knowledge to cater to student diversity and to broaden students' concept of the world. The changing cultural composition of societies is one specific case of a change that is making it necessary for teachers to improve their teaching skills and abilities (pedagogy) as well as their knowledge of the content they teach to be culturally responsive in their teaching practice. Not only should professional development be viewed in terms of its impact on the teacher force, but also a case can be made for it to include components that relate to minorities, as they make up the student population as well as the teaching profession.

Teachers should promote inclusion in schools (Fisher, Sax, & Grove, 2000; A. Moran, 2007). The teaching community is global. Internationally trained teachers have a wealth of information to share. They in turn need to be educated about certain approaches to teaching with which they might not be familiar. Ryan, Pollock, & Antonelli (2009) asserted that in Canada, which is a multi-cultural society, more work is needed if the teaching profession is to be more racially diverse. Professional development programs and courses should raise awareness of the cultural biases that may affect the learning experiences of both students and teachers. The provision of opportunities for teachers to express cross-cultural interactions, engage in self-reflection, and learn in a supportive and inclusive environment is important (McAllister & Irvine, 2002). Professional development should be a vehicle for transforming the teaching and learning that occur in schools. Professional development programs should include diversity training while utilizing best practices to promote teacher competencies and student growth.

2.3 Types of Professional Development

Professional development for teachers can take several formats. Guskey (2000) stated that the major models of professional development are training, observation/assessment, involvement in a development/improvement process, study groups, inquiry/action research, individually guided activities, and mentoring. Guskey (2000) posited that a combination of the models would provide an effective means of intentional and systematic professional development. There are other models of professional development such as brief workshops, conferences, or courses that usually

have no follow-up or long-term feedback (Robinson & Carrington, 2002). Consultants, heads of departments, principals, and school boards usually determine the practices, content, and pedagogy that teachers need to learn (Robinson & Carrington, 2002). Beaver (2009) in her critique of professional development argued that teachers have unique needs and directors of professional development programs should respect teachers' individuality and their self-direction.

Other types of professional development programs include mentorship for new teachers, generic coaches for school staff, or coaches of specific school content areas for school staff (Joyce & Calhoun, 2010). A distinctive characteristic of the coaching model is the one-to one relationship between two teachers (Kennedy, 2005). In this model, teachers act as mentors and provide support for colleagues. Teachers engage in self-directed professional development in several ways. Miller (2014) noted that professional development of teachers is an investment and professional activities should not be costly. Miller (2014) stated that there are several ways now available in the United States for teachers to be involved in their own professional development that do not cost much money. She suggested that teachers could be involved in learning by participating with online groups. The different approaches include Edcamp, in Ontario where attendees create workshop material online; Pinterest, where users share and manage images and links with relevant information; and Twitter, specifically #dchat, where participants from all over the world participate in education topics on Tuesdays. In addition, teachers participate in #engchat, hosted by nationally certified teachers in the United States who are available for discussions on Monday nights. Also on Twitter, there is #titletalk, which is co-hosted by teachers who talk about instructional methods and ideas for classroom.

Online webinars offer new training on teaching and learning techniques. Miller (2014) proposed that teachers are no longer bound to the instructional activities facilitated by schools and administrators as they have a wide array of self-directed learning (SDL) opportunities that will not limit their professional growth and can be done on their own schedule. In Chapter 5, I will provide descriptions, based on participants' experiences of some self-directed professional development opportunities available in Ontario.

When discussing the models of the mathematics professional development, Sparks and Loucks- Horsley (1989) named individually guided staff development as a type of professional development, in which teachers are better judges of their learning needs, are self-motivated, and can direct their own learning. Self-directed professional development that is the focus of this study aligns with individually guided staff development.

2.4 Self-Directed Professional Development

Self-directed professional development is professional development that is internally motivated and arises from the teacher's own initiative (Eekelen et al., 2006; Mushayikwa & Lubben, 2009). Teachers can choose to act as their own brokers for learning (Cobb & Smith, 2008), which requires that they determine through reflection on practice, observation, and students' responses the kind of professional development activities that are important for their professional growth and their students' success. Teachers who are involved in self-directed professional development self-regulate their learning and manage their social and contextual environments to achieve and influence their learning goals (Butler, Lausher, Jarvis-Selinger, & Beckingham, 2004; Buzza &

Allinotte, 2013; Cho & Heron, 2015). Through self-regulation, teachers monitor their learning needs and seek learning opportunities to fulfill their needs. Through self-regulation teachers' belief systems guide them in aligning their professional learning needs as they progress in their teaching career as life-long learners (Spruce & Bol, 2015).

Teacher reflection is identified as the driving force behind the professional development of many educators. Cranton (1996) stated that becoming self-directed in one's practice requires reflecting on the things one does as a professional. She further suggested that educators are expected to be autonomous self-directed professionals, maintaining best practices and implementing novel activities to stimulate professional growth. Teachers have the autonomy to control and seek resources to support their own learning. Traditional teacher professional development, that is, professional development directed by governments or school boards, does not allow or encourage teachers to be responsible for their own professional development (Cranton, 1996). Self-directed professional development, on the other hand, is more likely to allow teachers to determine what they need to learn to be effective. This learning is done at the place and time convenient to each teacher.

Chiappetta (2006) credited self-directed professional development for stimulating teachers' self-directed professional development activities as ideal for teachers as they determine their learning needs and seek to fill them. In a postmodern society like ours, teachers are challenged to use best practices, facilitate their own professional development, and foster student development by creating authentic learning experiences. Chapman (2013) asserted that there is a role for self-directed professional development,

as it can transform teachers' thinking in mathematics education to promote new and varied ways of approaching mathematical concepts. Self-directed learning (SDL) as done by the teacher is an avenue for exploring questions generated because of one's practice (Slavit & McDuffie, 2013). Slavit & McDuffie (2013) further stated that:

> When these questions are constructively negotiated by a teacher community, buy-in is almost certain and this buy-in supports teachers' attitudes that improved practice should remain a priority in their work and in turn focuses their attention on ways to change. (p. 104)

Teachers who are actively engaged in their own professional development demonstrate a willingness to learn and to be engaged in reflection and learning (Minott, 2010). Minott (2010) has identified the following benefits of self-directed professional development and they include (a) addressing individual needs, (b) empowering teachers, (c) leaving knowledge creativity to the teacher, and (d) promoting reflection. When teachers engage in self-directed professional development, they are addressing their professional needs while being empowered to make professional judgments about their learning needs. Reflective teaching is important for knowledge building, as it facilitates introspection in an individual's teaching style, content knowledge and an evaluation of student learning (Raelin, 1997; Stuessy & Nazier, 1996). Self-directed professional engages the teacher in professional learning and provides a framework on which to foster and address changes in practice. Sztajn, Campbell, and Yoon (2011), while identifying concepts for models of mathematics professional development, encouraged individually guided staff development in which teachers address their leaning needs and goals.

Self-directed and active teacher learning are important in professional practice of teachers (Powell, 2013). In a study on how teachers entering the profession over the past five decades made sense of their professional lives, Tang and Choi (2009) concluded that teachers who were engaged in self-directed professional development were driven by their moral commitment to teaching. This moral commitment was related to the agency that professional development knowledge afforded teachers (Tang & Choi, 2009). Tang and Choi (2009) further added that self-directed professional development is characterized by the teacher's active agency in integrating several sources of knowledge and applying such in proper context. Soini, Pietarinen, and Pyhältö (2016) while exploring teacher learning in terms of teacher professional agency concluded that the students themselves are also a source of knowledge for teachers in the teacher- student interaction, since teachers decide what knowledge they need to acquire. Using the knowledge gained from teacher-student interaction, teachers learn about students' needs and the challenges they face in schools. Since professional development is a continuation of teachers' growth to provide students meaningful learning, self-directed professional development can support ongoing professional development which teachers engage in throughout their teaching career.

2.5 Self-directed Learning

Teachers are not passive about their learning needs. They are seeking ways to be engaged in learning that is relevant to their content knowledge and pedagogy. Coles and Knowles (1993) maintain that teachers' input should be sought by school organizations, so that they can give voice to their interests and learning needs. In addition, teachers

negotiate their roles and subsequent responsibilities as educators whose mandate requires fostering and encouraging student engagement (Cole & Knowles, 1993). The ability to reflect on one's pedagogy and act on that reflection indicates growth as a teacher (Darling-Hammond, 1996; Giroux, 1988; Minott, 2010; Noddings, 2001) Teachers who engage in self-directed professional development place a high priority on their learning needs and seek opportunities to have their questions answered and explore ways to improve their knowledge. Engagement in self-directed professional development activities is a sign that teachers value their professional development.

Learning as defined by Schunk (2000) occurs when people "become capable of doing something differently" (p. 2). Learning, therefore, is reflected by adapting new ways of doing things and changing or modifying previous actions. Little (1999) argues that the central motivations and occasions of teacher learning are closely linked to the actual work of teaching and the circumstances in which teachers teach. Teacher learning therefore is contextual and this research seeks to find out how teachers engage in learning through self-directed professional development activities in mathematics.

What is self-directed learning (SDL)? It is the individual's decision to study a topic or engage in learning of his or her own volition. The learner decides on the material that needs to be learned and organizes the learning process to fit current needs (Knowles, 1975a, 1975b). Knowles (1978) opined that SDL is initiated by the adult and this process may or may not involve others. Individuals identify their own learning needs and goals, following which they acquire the resources to achieve these goals. Trotter (2006) identified two traits of adult learners: (a) they determine the direction of their learning,

and (b) they have a wealth of experience and use their experience as a resource. Knowles added that the individual is actively involved in measuring the learning outcomes. SDL has its roots in andragogy. Andragogy, according to Knowles, is related to adult learning and is characterized by learners being responsible and having control over what they learn, which produces independent and capable individuals. Merriam (2001), in discussing Knowles' andragogy, stated that learners are involved in the planning, diagnosing learning needs, and formulating learning objectives, after which they design learning plans, carry out these plans, and evaluate them.

The goals of SDL include helping learners develop the capacity for self- direction, supporting transformational learning, and promoting emancipatory learning and social action (Merriam, 2001). Elementary teachers are adult learners and those who engage in professional development that they themselves initiate are involved in SDL.

2.6 Twenty-First Century Skills and Mathematics Education

Rotherham and Willingham (2009) posited that educators, politicians, and business leaders are united around the idea that students need twenty-first century skills to be successful today. Twenty-first century skills are inherent in mathematics education as noted in the *Ontario Curriculum Grades 1-8* (2005), where it is stated that the study of mathematics equips students with knowledge, skills, and habits of mind that are important for functioning in the society. Skills necessary for the twenty-first century identified by Joyce and Calhoun (2010) included critical thinking and problem solving and entrepreneurial literacy as well as information and communication technologies. Furthermore, twenty-first century skills must be integrated into teaching students (Smith

& Hu, 2013). The professional development of the teacher should also include the learning to teach these skills. Twenty-first century skills are important for students to participate actively and effectively in civic society.

The Organization for Economic Cooperation and Development (OECD) in its report on the 2012 PISA scores included mathematical literacy as a criterion for students to achieve using their reasoning abilities to explain and predict phenomena, all of which are critical thinking skills (OECD, 2013). In addition, the Ontario Ministry of Education's (2004) *Report of the Expert Panel on Student Success in Ontario* provided a rationale for mathematical literacy, which is included in twenty-first century skills as: (a) more than executing procedures; (b) applying knowledge to the practical world; (c) interpreting data; (d) reasoning in numeric, graphic and geometric situations; and (e) communicating using numbers. These skills, while important in mathematics education, can be used in any subject. Thus, the pedagogy of the mathematics teacher is important in teaching these everyday skills to students. Further, Ontario Ministry of Education added:

> As knowledge expands and the economy evolves, more people are working with technologies or working in settings where mathematics is a cornerstone. Problem solving, the processing of information, and communication are becoming routine job requirements. Outside the workplace, mathematics arises in everyday situation after situation. Mathematical literacy is necessary both at work and in daily life. It is

> one of the keys to coping with a changing society. (Ontario Ministry of Education, 2004, p. 10)

In addition, OECD (2013) included mathematical literacy as a benchmark for students to achieve. Mathematical literacy is defined by the OECD as follows:

> Mathematical literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments needed by constructive, engaged and reflective citizens. (OECD, 2012, p. 3)

Ma and Singer-Gabella (2011) maintained that pedagogy should include designing and posing tasks that require students to use their reasoning abilities, formulate their own strategies for solving problems, and discuss their thinking in the process. Jarvis (2010) contended that the professional development of mathematics educators must be recognized as an important link in teacher practice. Darling-Hammond and Bransford (2005) confirmed that the role teachers play in the educational system is key to changes made in school and understanding how professional learning occurs is central to mathematics education as it helps teachers in preparing and providing effective teaching and learning resources that are beneficial to students. Mathematics education is a vital component of schooling in the twenty-first century. Simon and Schifter (1991) asserted

that when students learn mathematics, they are provided with opportunities and the stimulation to construct powerful mathematical ideas for themselves and to come to know their own power as mathematics thinkers and learners

2.7 Professional Development and Mathematics Education

There is a need for professional development in mathematics education. Teachers need both content and practice knowledge to be effective in helping students succeed in mathematics. Not only is teacher knowledge of content important in mathematics education but teachers' attitudes and beliefs about the subject impact their practices as teachers are expected to show a willingness to experiment with instructional ideas to influence student learning (Ross & Bruce, 2007; Wilkins, 2008). Wilkins (2008) conducted a study investigating 481 in-service elementary teachers' level of mathematical content knowledge, attitudes, and beliefs about the effectiveness of inquiry based instruction. Wilkins concluded that some teachers who were taught by teachers with traditional methods continued the same trend, while teachers who were less successful as students were willing to try new methods, and were more sympathetic towards students' learning needs.

Teaching mathematics to elementary students should include the use of different techniques, strategies and practices methodologies of introducing mathematics content, including twenty-first century skills. Roman (2004) and Berry and Ritz (2004) concurred that mathematics education is very important today as we live in the information age when mathematics is used to present that information.

Mathematics education in Ontario has undergone significant changes over the past three decades. The identifiable goal is for students to be competent in mathematics literacy and to be able to see mathematics as a practical subject where students show progress in mathematics skills from one grade level to the next. As I stated earlier, the Ontario government, through funds earmarked by the Ministry of Education (MOE) for improving mathematics teaching and learning, aims to promote collaboration with educators, students, and parents and to mobilize best practices in mathematics research to enhance effective learning, teaching, and providing professional development for teachers. Further, the *Ontario Curriculum for Mathematics Grades 1-8* (2005) explicitly highlighted the importance of mathematics learning for students by including the expectations that students acquire higher-order thinking skills. Kajander (2010) added that there is a need for teachers to deepen significantly their mathematical and conceptual knowledge to be better prepared for classroom teaching.

Hill, Schilling, and Ball (2004) claimed that teacher knowledge is important in mathematics education. They further state that more attention needs to be placed on teacher education as research has shown that over the past two decades the teachers' knowledge of mathematics has become an object of concern. Goldsmith et al. (2014) in an extensive literature review on the professional development of mathematics teachers noted that the continuous learning in which teachers are engaged influences student learning.

The teaching of mathematics provides opportunities for students to develop higher-order thinking skills as they explore and analyze information to arrive at plausible

solutions. The teaching of mathematics fulfills the role of providing students with opportunities for mathematical knowledge construction (Simon & Schifter, 1991). In addition, researchers have contended that one of the strongest factors influencing student outcomes in mathematics education is teacher classroom practice (Sutton & Krueger, 2002). The teachers' mathematical understanding also helps them to be alert to students' ideas and needs to help further these ideas. Leikin and Zazkis (2010) asserted that when teachers are knowledgeable and skilled they give students more autonomy in the classroom, which fosters an openness in the teaching and learning process. This openness encourages an atmosphere in which teachers are willing to listen to student ideas and try new approaches to the teaching and learning of mathematics. To produce competent students, mathematics teachers should positively influence student learning (Ross & Bruce, 2007).

2.8 Professional Development and Technology

The rapid advances in technology and the dynamic changes in the curriculum and the associated pedagogy have implications for teacher professional development and teaching in the twenty-first century (Leask & Youni, 2013; Polly & Hannafin, 2010). The twenty-first century heralded an increase in the number of technologies available for use at home, at school, and in the workplace. The advent of new technologies in the marketplace has made it necessary for teachers to use appropriate technologies in their teaching practice. Technology is used to support learning and teaching in many ways (Polly & Hannafin, 2010). Technology can support learning for both teacher and students. There are technological tools that promote student learning within the

classroom. Examples of teaching instructional technologies used in mathematics education are computer algebra systems, interactive white boards, hand held data-collection devices, and interactive presentation devices (National Council of Teachers of Mathematics, 2004).

Technology has influenced the way schooling is done today, resulting in a variety of tools that can capture the teaching and learning process as many classrooms from K to 12 have access to cameras, computers, videotaping software, and interactive whiteboards (Lawless & Pelligrino, 2007). Lawless & Pelligrino (2007) state that technology can be instrumental in helping to provide activities that enhance professional development but admit that technologies change rapidly, and teachers are constantly learning how to use them. Further, certain technologies support teacher professional learning. The use of technology can be instrumental in helping to provide activities that will enhance professional development.

Technology in its varied formats provide teachers with different avenues to professional development. With the use of technology, teachers can collaborate with others to effect change in their practice and learning. Teachers can collaborate with other professionals near and far using online platforms. This collaboration of teachers via social media platforms, such as twitter, blogs, and online information provides opportunities for learning, and sharing knowledge and practices. In addition, it is argued that social media allows users to create a culture with a balance between individual autonomy and collaborative work (Saville, 2013). While social media allows teachers to learn from and learn with others, there is the suggestion from recent studies that this

forum should be incorporated in professional development designs and should include learner directed, virtual formats through social media (Wallinger, 2016). In a study conducted by Visser, Evering, and Barrett (2014), they concluded that professional development through professional learning networks (PLNs) is the main reason why teachers are using Twitter as a learning forum. Through unconventional avenues of professional development such as social media, teachers share and learn about different and interesting ways to teach.

Professional learning networks in general terms are often thought of as groups of teachers who share ideas and work collaboratively to improve teaching and learning. Since teachers have easy access to Internet-based learning, it provides a readily available learning platform for professional development. Fucoloro (2012) contended that teachers have choices in the types of professional development activities in which they engage, and stated that teachers should be encouraged to move fluidly between traditional physical networks and virtual networks. This fluid relationship, Fucoloro (2012) contended, should be legitimized so that teachers can improve their practice and increase student engagement and learning by using best practices.

2.9 Implications for Professional Development of Teachers

The twenty-first century teacher is expected to be cognizant of students' learning needs and provide innovative ways to fill these needs. The teacher's role is more than keeping students in order and providing useful and relevant learning material. Darling-Hammond (2006) asserted that the teacher's role includes being increasingly effective in facilitating the learning of complex material for diverse student populations. Teachers

need to be cognizant of students' learning needs as they decide on the types of learning opportunities in which to engage students (Darling-Hammond, 2006).

Teachers must show that they are relevant, by teaching skills necessary for students' growth and development in mathematics education. Ma and Singer-Gabella (2011) maintained that the pedagogy of mathematics teachers should entail designing and posing tasks that require students to use their reasoning abilities, invent their own strategies for solving problems, and discuss their thinking. For teachers to be effective in providing students with analytic tools so that they are functionally literate in mathematics, they need to be given opportunities to promote and support their own learning (Remillard & Bryans, 2004). An alignment of teachers' needs and student learning is necessary so that teacher professional development and practice can complement each other. There should be support for both students and teachers that enables them to ask relevant questions about their learning. In addition, the diversity of school populations makes it necessary for mathematics to be culturally relevant to students who live in a global society (Namukasa, 2004). The professional development of the teacher is paramount in achieving educational goals and self-directed professional development may play a role in the achievement of such goals.

2.10 Chapter Summary

In Chapter 2, I provided a literature review on professional development that included self-directed professional development and mathematics education. This literature review underscored the importance of professional development for the mathematics teacher especially as it relates to the teaching and learning of twenty-first

century skills. Literature on professional development identified certain elements that are critical to successful professional development and highlighted how twenty-first century skills are embedded in mathematics education. These skills include problem solving, critical thinking and mathematical literacy. Ongoing professional development was identified as integral to teacher growth and essential in an era of new knowledge, new technologies, and new approaches to the teaching and learning of mathematics.

Chapter 3

Theoretical Framework

3.0 Introduction

In this chapter, I present the theoretical frameworks that undergird this study on elementary teachers' understanding of self-directed professional development in mathematics education. I used Mezirow's theory of transformative learning and Knowles's theory of learning—andragogy—to interpret and understand the views of teacher-participants who actively engage in self-directed professional development to inform their learning and classroom practice. Transformative learning theory and andragogy both informed my study as they provided a basis for understanding adult learning and teachers' involvement with self-directed professional development.

I considered other appropriate theoretical frameworks for interpreting teachers' experiences in self-directed professional development activities. Complexity theory, a possible framework looks at the interconnectedness of complex systems and the interactions within the system (Mason, 2008). However, complexity theory was not helpful in understanding teachers' experiences, as it did not focus sufficiently on the individual's understanding, perception, and engagement in an activity. Actor-network theory (ANT) was another possible framework to understand self-directed professional development. Actor-network theory traces the different ways in which human and nonhuman actors interact (Fenwick, 2010). However, while ANT looks at both human and non-human entities as actors, my focus on self-directed professional development

was mainly on teacher-participants' experience and especially how they perceived, engaged in, and understood self-directed professional development in their practice.

This qualitative research on how elementary teachers perceive, engage in, and understand self-directed professional development was informed by a constructivist philosophical research paradigm. Constructivism is a recent philosophical research paradigm about the nature of reality, perception, and how people make sense of their world (Colburn, 2000; Creswell & Plano Clark, 2011; Patton, 2002a, 2002b; Schwandt, 1994). In addition, Creswell and Plano Clark (2011) stated that in constructivism there are multiple realities where participants attach meaning to their experiences.

Constructivism as a philosophy in social science research has roots in constructivism as a theory of learning. Constructivism was explored as a theory of learning in which learning is understood as a process of constructing meaning from actions with materials and interactions with other learners (Fosnot & Perry, 1996). Radical Constructivism as proposed by Von Glasserfield (1995) develops the notion that individuals construct knowledge based on their experiences. Barnett (1996) in describing constructivism stated that it is a theory whereby individuals create their own understandings of the universe. The understandings as proposed by Barnett (1996) are the result of experiences and personal reflection. Constructivism was further developed to address learning with others and in the context of micro and macro cultures, social and cultural constructivism. Individuals make meaning from their interaction with others and with their physical and socio-cultural environment.

Guided by constructivist understanding of how individuals experience reality with

others, the researcher looks at the complexities of the lived experiences of participants and the meanings they attach to them (Patton, 2002a, 2002b; Schwandt, 1994). These meanings are "influenced and shaped by reflection, mediation, and social interactions" (Lambert et al., 2002, p. 7). The central question undergirding this research was: How do elementary teachers perceive, engage in, and understand the role of self-directed professional development in mathematics education? This research, while focusing on self-directed professional development of elementary mathematics teachers, explores teacher learning because learning and knowledge creation is an integral part of the professional development process (Hyslop-Margison & Strobel, 2008).

3.1 What is Learning?

There are different conceptualizations of learning. Leberman, McDonald, and Doyle (2006) stated that learning is not limited to specific skills, but that it also encompasses socio-cultural, cognitive, and behavioral characteristics. Learning is a condition of being human as individuals acquire information as they participate in their daily activities (Mezirow, 2000). It is the process of using prior knowledge or a revised interpretation of one's experience to guide understanding, appreciation, and action (Mezirow, 2000). This learning, however, could also be purposeful. It could also be "incidental, a by-product of another, involving intentional learning, or mindlessly assimilative" (Mezirow, 2000). Learning therefore is an activity that can be planned, or it could be the consequence of other actions which makes it both deliberate and unintended.

A review of 23 studies by Taylor (2000, 2007) revealed findings such as capturing the meaning-making process and changes in views of adult learners that supported

Mezirow's conditions for fostering transformative learning. It is important to note that transformative learning occurs because of personal factors. Learning occurs in four different ways: by elaborating existing frames of reference, by learning new frames of reference, by transforming points of view, or by transforming habits of mind (Mezirow, 2000). The role of Mezirow's theory of transformative learning and andragogy in this study is to provide the lens through which I explore the phases involved in adult learning as well as the effect of engaging in learning opportunities on teachers.

3.2 Transformative Learning Theory

Jack Mezirow, an adult education specialist, first articulated transformative learning theory. Mezirow's theory of transformative learning emerged from a large qualitative study he conducted with women who returned to school after being out of educational institutions for a time. Based on their research findings, Mezirow and his team concluded that the participants had undergone perspective transformation (Mezirow, 1978). I adopted this adult learning theory to gauge teacher-participants' understanding of self-directed professional development. Transformative learning offers insight into the factors that influence learning by adults and how that knowledge is communicated. Mezirow (2000) defines transformative learning as:

> The process by which we transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mind-sets) to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action. (pp. 7-8)

Mezirow (2000) indicated that perspective transformation includes psychological, convictional, and behavioural changes. Psychological changes relate to how one understands oneself. Convictional change occurs when individuals revise their belief systems. Behavioural change refers to lifestyle adjustments made by individuals. Transformative learning (Cranton, 1994, 1996; Mezirow, 1991, 1995, 1996) is the process of effecting change in a frame of reference. Adults have acquired a coherent body of experience, associations, concepts, values, feelings, conditioned responses, and frames of references that define their life world (Mezirow, 1996). Frames of reference are the structures of assumptions through which people understand their experiences and use them to guide decisions and direct actions (Mezirow, 1995).

Mezirow (1995) assert that frames of reference help to shape expectations, perceptions, cognition, and feelings. Once frames of references are set, we automatically move from one behaviour to the next (Mezirow, 1996). Individuals have a strong tendency to reject ideas that do not fit their preconceptions, labeling those ideas as unworthy of consideration—aberrations, nonsense, irrelevant, weird, or mistaken. When circumstances permit, transformative learners change and their frame of reference changes as well (Mezirow, 1996). This change results in a more reflective move toward a frame of reference that is more inclusive, discriminating, self-reflective, and integrative of experience (Mezirow, 1996). A frame of reference encompasses cognitive, conative, and emotional components (Mezirow).

An added dimension to the notion of transformation is that adults have acquired experiences that they use to determine their world (Cranton, 1994, 1996; Mezirow, 1991,

1995, 1996). Mezirow (1996) summarized transformation learning theory in 12 propositions. The propositions identified by Mezirow included: (a) learning as a process that guides one to action, (b) a belief is a habit that guides to action, (c) learning that transforms one's actions, (d) competence in coping with the world involves reflection and problem solving, (e) learning as instrumental and communicative, and (f) transformational learning that requires the individual to make an informed decision. Further, Mezirow identified ten phases of transformative learning as outlined in Table 3.1, which describes the process through which the transformation in learning occurs.

Table 3. 1 Mezirow's (1978) Ten Phases of Transformative Learning

Phase	Transformative Learning
Phase 1	A disorienting dilemma
Phase 2	A self-examination with feelings of guilt or shame
Phase 3	A critical assessment of epistemic, sociocultural, or psychic assumptions
Phase 4	Recognition that one's discontent and the process of transformation are shared and that others have negotiated a similar change
Phase 5	Exploration of options for new roles, relationships, and actions
Phase 6	Planning of a course of action
Phase 7	Acquisition of knowledge and skills for implementing one's plans
Phase 8	Provisional trying of new roles
Phase 9	Building of competence and self-confidence in new roles and relationships
Phase 10	A reintegration into one's life based on conditions dictated by one's perspective

Source: Kitchenham (2008)

Cranton (1994) claimed that Mezirow's theory of transformative learning is comprehensive and aptly describes how learners understand and validate the meaning of their experiences based on their assumptions, beliefs, and values. I used this theory to understand the learning experiences of teacher-participants who self-identified as engaging in self-directed professional development. The 10 phases of transformative

learning as described in Table 3.1 provided a base on which to understand and interpret teacher-participants' experience and practices in self-directed professional development. Several of Mezirow's phases of transformation are evident in teacher-participants' experiences. I explore these further in Chapter 6.

Mezirow (1978), in his study on women who had returned to school after a long absence, discovered that their assumptions about life and their frame of reference also changed. Mezirow called this change *perspective transformation*, where the women now had different ways of responding to situations in their lives (Fleischer, 2006). The women in this study experienced changes in their perspectives, which changes in turn guided future actions. Perspectives relate to the dimensions of thought, feeling, and the individual's will (Mezirow, 1978).

> Perspectives are a set of beliefs, values, and assumptions that we have acquired in our life experiences. These perspectives serve as a lens through which we come to understand ourselves and the world in which we inhabit. (Dirkx, 1998, p. 4)

Further, perspectives are a part of who we are as individuals, inclusive of our beliefs, values systems, assumptions, and how we use information to direct actions (Dirkx, 1998; Fleischer, 2006; Mezirow, 1990). Transformation brings new perspectives to the lives of individuals and allows them to make meaning of their life experiences. Individuals use their perspectives and beliefs to determine the course of action that will be involved in addressing their situation.

> To its favor, transformative learning was found to be effective at capturing the meaning-making process of adult learners, particularly the learning process of paradigmatic shifts. Much of the research confirmed the essentiality of critical reflection, a disorienting dilemma as a catalyst for change, and many of the phases of the transformative process described by Mezirow. (Taylor, 2007, p. 171)

The basic premise of Mezirow's transformative learning theory is that adults participate in reflection, identify problems that they face, make judgments, and set priorities to take action to change the situation through their own initiative. Mezirow's theory highlights that attitudes and beliefs formed early in life is the basis for actions done later in life. Several studies have been conducted that focused on the use of transformative learning by adults, some of which were in educational settings (Allen, 2008; Pierre, 2004). Transformational learning is fundamentally concerned with construing meaning from experience as a guide to action (Clark & Wilson, 1991). Other scholars, most notably Cranton (1994, 1997), have elaborated upon Mezirow's original theory and have added that transformative learning was effective in understanding the meaning-making process of adult learners (Taylor, 2007).

Mezirow (1991) in developing the theory of transformative learning drew from Kuhn, Freire and Habermas as shown in Table 3.2.

Table 3. 2 Transformative Learning Theory and Related Theories

Related Theories	Transformative Learning's (Mezirow, 1991) Facets
Kuhn's (1962) paradigm	Perspective transformation Frame of reference Meaning perspective Habit of mind
Freire's (1970) conscientization	Disorienting dilemma Critical self-reflection Habit of mind
Habermas' (1971, 1984) domains of learning	Learning processes Perspective transformation Meaning scheme Meaning perspective

Source: Kitchenham (2008, p. 106)

It was primarily Habermas' work on the domains of learning that informed Mezirow's theory. Habermas suggested that communication and instrumental learning are important. Instrumental learning involves learning processes that are primarily to control and manipulate the environment or other people (Mezirow, 1990). Instrumental learning suggests problem solving. Communicative learning relates to the adult trying to find meaning. In self-directed professional development, teacher-participants used both constructs of learning as they sought ways to facilitate self-directed professional development that would guide their action. In my research, I used this notion to determine how teacher-participants solved the problem of their professional development needs.

3.3 Connections between Transformative Learning Theory and Constructivist Theory

Mezirow's theory of transformative learning has parallels with constructivism as the experiences of adults influence what they learn and how they respond to that knowledge gained. Learning therefore is dependent on the need to know or change and involves reflection on one's goals. The constructivist thought that guides this research is that the learner is not passive, but is actively engaged in constructing knowledge and in the processes involved in the creation of this knowledge (Sutherland, 1997). Constructivism is grounded in the pioneering work Piaget who asserted that knowledge is produced based on one's experiences (Piaget, 1969). The constructivist position aligns closely to Mezirow's view of transformative learning, where perspectives change because of experience.

In the social constructivist paradigm, participants provide their understanding and speak from meanings that arise from their interaction with others as well as from their personal histories (Creswell & Plano Clark, 2011). Teachers' understanding of self-directed professional development can be understood through their individual experiences, hence the use of the constructivist lens to frame this investigation. In the data analysis phase, the researcher provides quotes to illustrate the different perspectives of the participants. As well, the constructivist paradigm inclines the researcher to identify biases and experiences that they bring to the research (Creswell & Plano Clark, 2011). As a researcher who has experienced self-directed professional development, I am aware of some factors that may lead teachers to engage in self-directed activities. My

biases influenced this research and the nature of the investigation. Researcher reflexivity, which is an acknowledgement of one's relationship with the phenomenon being studied is outlined in Chapter 4.

Mezirow asserted that our perceptions are influenced by our habits that constitute our frame of reference. A frame of reference, according to Mezirow (2000), is composed of two dimensions: a habit of mind and resulting points of view. Habits of mind are assumptions that are "broad predispositions that determine the meaning of experience" (p. 17). There are diverse habits of mind such as socio-linguistic (cultural canon, social norms, moral-ethical [conscience, moral norms], philosophical [religious doctrine, philosophy] and aesthetic [values, tastes, attitudes, standards].

Mezirow (2000) argued that a point of view consists of our attitudes, beliefs, interpretations, and the judgments that we make. In effect, this means that our values and how we feel about ourselves help to determine our identities. Mezirow (2000) asserted that our emotions play a critical role in the formation of our frames of reference. He stated that individuals defend their frames of reference because they are intertwined with emotions and identities. The views of others are judged based on the standards set by points of view. Hence, there is a close relationship between the sense of self and the value system. The goal of transformational learning is to provide grounds for action. This learning, as is the case with constructivist learning, is active and involves construction of knowledge that is deeply entangled with people's identities (Mezirow, 2006).

3.4 Limitations of Mezirow's Theory of Transformative Learning

Mezirow's theory of transformative learning has been hailed as having a significant impact on the field of higher education (Taylor, 2000) and it is a common theme at presentations on adult education. Taylor (2000) contended that the transformative learning theory is "inadequately understood, researched and presented in the professional literature" (p. 27). While the learning theory has widely been adopted to understand adult learning, it is important to understand whether the transformative learning theory adequately explains teachers' experiences with self-directed professional development in elementary mathematics education.

Another limitation of Mezirow's transformative learning theory is the notion that learning occurs because of a disorienting dilemma. The women in Mezirow's initial study experienced a disorienting dilemma that ultimately led to learning experiences. However, learning does not occur primarily because one is undergoing a dilemma. Learning can occur for many reasons. Learning can result from play, from the desire to learn, and from instruction (Sherin, 2002; Yoshikawa, Weiland, & Brooks-Gunn, 2016).

Brookfield (2000) also argued that when the term transformative is added to any form of practice, it is imbued with weighty significance and devalues the main part of teachers' work, which involves "engaging people in deepening their understandings and actions" (p. 140). Clark and Wilson (1991) asserted that experience cannot be separated from context as they shaped and provided an interpretive frame from which perspective transformation is viewed. While context may not be a major focus of the theory, it is inevitable that teacher-participants' contexts in terms of how they view professional

development, along with their reflection, may influence their classroom practice. I address the issue of context by being aware that while perspective transformation occurs because of one's critical reflection, it occurs within a certain context. The context could be the school culture, the individual experiences, and the community environment in which the teacher-participants work. The context could be related to a teacher-participant's own frame of reference and habits of mind. Living in the Internet age facilitates teachers' self-directed learning (SDL) opportunities. I used Mezirow's theory to understand how teachers engage in self-directed professional development because this theory values an open-inquiry approach capable of registering and tracking disruptive and newly emergent pathways of experience and learning (Patterson, Munoz, Abrams, & Bass, 2015).

This investigation of teachers' understanding of self-directed professional development is influenced by the notion of learning. Learning, as defined by Schunk (2000), occurs when people "become capable of doing something differently" (p. 2). Learning therefore requires that an individual adapts new ways of doing things and change or modify previous actions. Little (1999) argued that the central motivations and occasions of teacher learning are closely linked to the actual work of teaching and the circumstances in which teachers teach. Learning therefore is contextual and in this research, I sought to find out how teacher-participants engage in learning through self-directed professional development activities in mathematics. The construct of andragogy as outlined by Knowles (1984) has some basic assumptions of learning that informed this inquiry.

3.5 Andragogy

Andragogy is the science and art of studying and helping adults to learn (Knowles, 1984). Andragogy refers to adult learning in which learners are responsible are responsible for and have control over what they learn, producing independent and capable individuals (Knowles (1984). Knowles made key assumptions about the adult learner. He posited that adult learners can direct their own learning and have independent self-concepts. The adult learner has a wealth of life experiences that serve as a rich resource for learning. Further, in a manner like children and youth, adult learners are problem-centered and are interested in the immediate application of the knowledge learned. In addition, adult learners are intrinsically motivated to learn and their learning needs are related to their personal circumstances. Drawing on Knowles' theory on adult learning, Leberman et al. (2006) identified the individual's readiness to learn and a change in perspectives as common characteristics of adult students.

Kolb (2005) offers another view about adult learning. He states that learning is as a process rather than a product. Furthermore, Kolb, added (a) relearning as it is grounded in one's beliefs, (b) the process of learning requires the resolution of conflicts between diametrically opposed modes of adaptation to the world, (c) learning is a holistic process of adaptation to the world, (d) learning involves transactions between the person and the environment, and (e learning is the process of creating knowledge.

One of the aims of adult education is to help learners become aware of the context of their understanding and beliefs, to reflect actively on their assumptions, to become engaged in the discourse, and to act based on their reflection. This investigation examined how teacher-participants learned through self-directed professional

development activities in mathematics education and took actions based on their learning experiences. Both Mezirow's transformative learning theory and Knowles's model of andragogy assume that adults choose learning activities after they have experienced a situation in their lives that demands action. The two theoretical frameworks are in alignment with this study and complement each other as they are both associated with adult learning and the internal motivation to learn. Transformative learning theory and andragogy support the notion that adults take an active role in the learning process. Using this model helped me understand how teacher-participants are engaged in their own learning. Furthermore, I sought to understand whether teacher-participants in this research experienced changes in their perspectives about learning and its role in their professional development

3.6 Chapter Summary

In Chapter 3, I presented the theoretical frameworks of transformative learning and andragogy that underpin this study on self-directed professional development in elementary mathematics education. Ten phases of Mezirow's theory were outlined and the key assumptions related to Knowles theory of adult learning discussed. To frame my understanding of teacher-participants' perception, understanding, and engagement in self-directed professional development, I related the research paradigm of constructivism to Mezirow's theory of transformative learning. In addition, I provided a guide to understanding habits of mind and perspective change as identified by Mezirow (2000).

Chapter 4

Methodology and Methods

4.0 Introduction

In this chapter, I outline the methodological approach that guided this qualitative investigation on self-directed professional development in elementary mathematics education. The overarching question that provided the framework for this investigation is: How do elementary teachers perceive, engage in, and understand the role of self-directed professional development in elementary mathematics education? The goals of this chapter are to: (a) outline the rationale for choosing a qualitative approach, (b) explain the methodological approach, (c) describe the data collection and analysis procedures, and (d) outline the researcher position.

4.1 Rationale for Qualitative Approach

Patton (1990) argued that methodological appropriateness is the primary criterion for judging methodological quality. He pointed out that the methodology chosen for any research should closely align to the research question, as this determines the techniques and the research instruments used for data collection. In some qualitative studies on professional development, researchers have used narrative inquiry (Wood, 2000), and case studies (Fermanich, 2002). In this inquiry, I used a qualitative stance to understand how teacher-participants' perceive, engage in and understand self-directed engagement in and understanding of self-directed professional development. Merriam (2009) summed

up the core of qualitative research as “to achieve an understanding of how people make sense out of their lives, delineate the process (rather than the outcome or the product) of meaning making, and describe how people interpret what they experience” (p. 14). In this research teachers would be making sense of their experiences with self-directed professional development.

McMillan and Schumacher (2006) asserted that one’s reality and one’s truth are multilayered and interactive making it necessary to use qualitative research to explore and understand self-directed professional development as experienced by elementary mathematics teachers, especially since their experiences are likely to be different from each other. The different ways of experiencing and the different approaches to the experiences are influenced by teachers' individual contexts. My decision to use a qualitative approach in this study was influenced by the perspective that individuals attribute meaning to their experiences (Schultz, 1967). Teacher-participants discussed their experiences in elementary mathematics and how they attributed meaning to these experiences with self-directed professional development.

My use of qualitative research to address this investigation is consistent with the epistemological view that one’s understanding of a phenomenon is unique to the individual because of factors that are peculiar to that individual. The need to present a detailed view of teacher-participants’ experiences was another motivating factor for using a qualitative stance (Creswell, 2003; Creswell, 1998). When participants share their understandings, shaped by their experiences, which are in turn shaped by their interaction with others, they are involved in meaning construction (Creswell & Plano Clarke, 2011).

As I indicated in Chapter 3, in this research I used the constructivist paradigm, which recognizes multiple participant meanings. In the paradigm, there are multiple realities, determined by individuals' context. Mezirow (2000) stated that individuals' perspectives change because of their learning experiences, wherein they construct new knowledge that results in a change in behavior. Fox (2001), in examining the constructivist theory of learning, identified elements in the learning process that include: (a) learning is an active process; (b) knowledge is constructed, rather than innate or passively absorbed; (c) all knowledge is personal, idiosyncratic, and socially constructed; and (d) learning is essentially a process of making sense of the world. Teachers in this investigation were from different backgrounds and they engaged in teaching practices based on the realities in their classrooms.

4.2 Phenomenography

Given my interest in how teachers perceive, engage in, and understand self-directed professional development, phenomenography was the methodology I chose to help me understand the experiences of the teacher-participants. Phenomenography helped me to categorize and theorize about teacher-participants' experiences with self-directed professional development.

Phenomenographic research conducted by Marton and his colleagues in Sweden, investigated the qualitatively different ways in which students experienced the learning of mathematics concepts and process of teaching (Richardson, 1999). Marton (1994) described phenomenography as an empirically based approach that aims to identify the qualitatively different ways in which different people experience, conceptualize,

perceive, and understand various kinds of phenomena. Phenomenography continues to prove fruitful for empirical research, as there have been several studies related to varying ways of experiencing phenomena, including concepts of learning (Limberg, 2008). Phenomenography collects evidence to show that different range of conceptions exists within the population under study (& Pong, 2005). The population under study may discern more than one conception because their way of seeing and feeling about a conception may change. (Marton & Pong, 2005). Within this phenomenographic framework, learning takes a central role as it represents a qualitative change from one conception concerning some aspect of reality to another (Richardson, 1999).

Marton (1981) stated that phenomenography aims at description, analysis, and understanding of experiences. It offers a "second order" perspective that aims at describing people's experiences of the world; phenomenography is aimed at "experiential description" (p.180). The experiential descriptions that teacher-participants engaged in for this research focused on their perception, and how they engaged in and how they understood self-directed professional development in the context of elementary mathematics education. Phenomenography continues to prove fruitful for empirical research, as there have been several studies related to varying ways of experiencing phenomena including concepts of learning (Limberg, 2008).

Marton (1981) explained that "essence" is central to phenomenography and although the meaning varies, it mainly refers to the common intersubjective meaning of the phenomenon. A phenomenon is experienced in a relatively limited number of qualitatively different ways. Marton and Pong (2005) added:

> Traditional phenomenographic research aims to investigate the qualitatively different ways in which people understand a phenomenon or an aspect of the world around them. These different ways of understanding, or conceptions, are typically represented in the form of categories of description, which are further analyzed about their logical relations in forming an outcome space. (p. 335)

The question then arises, what is a conception? A conception is the basic unit of description in phenomenographic research. It has been referred to in various ways such as the ways of conceptualizing, ways of experiencing, ways of seeing things, ways of apprehending, and ways of understanding. Marton and Pong (2005) proposed that the reason for using so many synonyms is that although no one term completely expresses the idea completely, they all do to a certain extent. One can "discern and focus upon conceptual features just as one can discern and focus on sense-related features" (p. 336). Merleau Ponty (1962) stated that there is a connection between an individual's understanding and perception in relation to one's experiences. Using phenomenography helped to clarify teacher-participants' understanding of self-directed professional development or the learning that occurs to facilitate this process. In this research, phenomenography was concerned with the teacher-participants' conceptions of self-directed professional development in the teaching of mathematics in elementary schools.

In phenomenographic research, the focus is on the variation in the experiences of a group of people (Trigwell, 2006). In phenomenography, it is argued that individuals experience the same situation in different ways. In effect, six individuals may experience

learning about fractions, but each in a different way. Trigwell (2006) assert that meaning is relational, that is, meaning is contained in a relationship between the individual and the phenomenon, so meaning in this study is attributed to each teacher-participant's experience with self-directed professional development and the context in which it occurs (Trigwell, 2006). The product of phenomenographic research is a set of categories of description in which understandings of a concept or event are logically and hierarchically related (Trigwell, 2006). The goal of phenomenographic research is to have all conceptualizations of the relevant concept become evident in a structured format (Greasley & Ashworth, 2007). The descriptions of the experiences given by participants enable the construction of the outcome space.

To understand the tenets of phenomenography, I needed to understand phenomenology, as both share similarities. The two qualitative research approaches are similar in that they are used to investigate human experiences. Phenomenography investigates the variation in the experience of a phenomenon, groups those variations in the form of categories of description, and sets the categories in logical or otherwise meaningful relationship with each other (Ashworth & Lucas, 1998).

Phenomenological research is the study of lived experience: phenomenology is the study of the world as people experience it rather than as their categorization and conceptualization of it (Lewis & Staehler, 2010; van Manen, 1984). Phenomenology is interested in the phenomenon and what it is, whereas phenomenography is concerned with the different perceptions that people have of the phenomenon in question, as well as the way in which they proceed to categorize and theorize about it. Van Manen (1990)

added that research that is phenomenological is a search for what it means to be human and what lies at the core of our being. Moran (2000) stated that phenomenology places the emphasis on describing the phenomenon. Conversely, phenomenography attempts to look at the analytical categories of experiences in a phenomenon (Marton, 1981). The essence of phenomenography is that of a "non-dualist qualitative, second order perspective, which describes the key aspects of the variations of the collective experience of a phenomenon instead of the experiences of the individuals" (Trigwell, 2006, p. 368).

Moran (2000), in explaining phenomenology, stated that phenomenology is best understood as an anti-traditional style of philosophizing, in describing the phenomenon. Phenomenology captures the essence of the phenomenon while phenomenography is directed at studying the variations in the experience of the phenomenon (Akerlind, 2008; Limberg, 2008; Rose, Heron, & Sofat, 2005; Sin, 2010). Figure 4.1 delineates the similarities and differences between phenomenology and phenomenography.

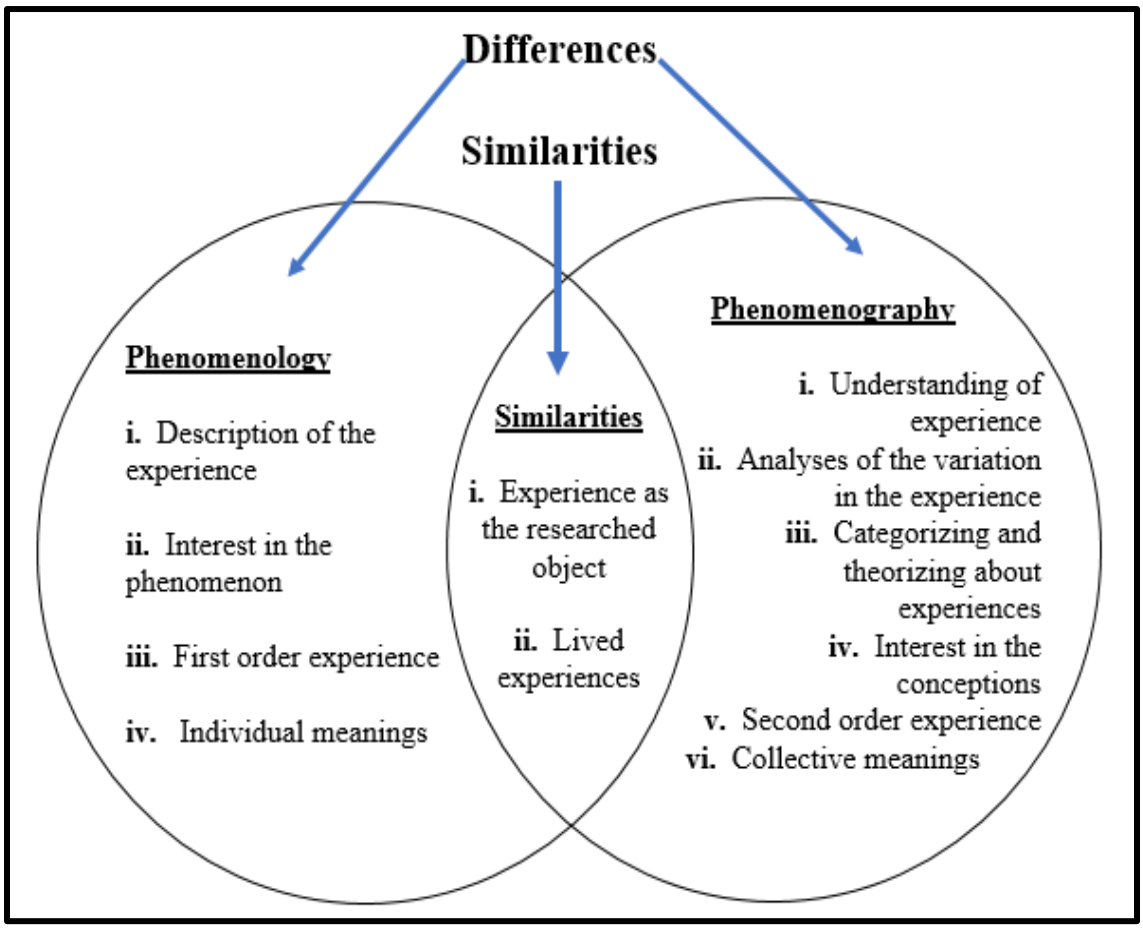

Figure 4. 1 A Venn diagram showing similarities and differences between phenomenology and phenomenography

Although the two approaches share similar features as identified in Figure 4.1, especially as they both investigate humans and their experiences; I chose phenomenography because of its focus on the perceptions of individuals. The primary concern in this research is about how teachers perceive, engage in, and understand self-directed professional development. Phenomenography is the study of the limited number of qualitatively different ways that people experience the world (Goh, 2013; Marton, 1994). Phenomenography investigates the variation in the experience of a phenomenon, groups those variations in the form of categories of description, and sets them in logical or otherwise meaningful relationship with each other in what is called an outcome space (Ashworth & Lucas, 1998). The outcome space identified in phenomenographic research represents "the possible ways of experiencing the phenomenon in question, for the population that is represented by the sample" (Akerlind, 2002, p. 2). Several categories formed the outcome space that I discussed in Chapter 6.

4.3 Ontology and Epistemology of Phenomenography

The ontological and epistemological assumptions of phenomenography form the framework for this study. The assumptions that undergird phenomenography are in line with the view that reality and knowledge are subjective, as they are determined by one's

context in the world. The ontology and epistemology of phenomenography influenced my decision to use this methodology as it aligns with my constructivist perspective that there are many ways of interpreting one's experience. Teachers' context in relation to their need for professional development in elementary mathematics influenced their learning and meaning making. Svensson (2006) proposed that the ontological and epistemological assumptions of phenomenography include the notion that knowledge is created through the agency of human thinking and human activity and is dependent on one's relationship with the world. Svensson added that an individual's contexts and perspectives guide their knowledge creation.

4.4 Trustworthiness in Phenomenographic Research

There are different ways of ensuring that a research study is trustworthy. In phenomenography, the trustworthiness of research is determined by the researcher (Cope, 2002). In Table 4.1, I highlight ways in which both the researcher and the data contribute to the trustworthiness of the data. There are multiple ways of interpreting social life and one's reality. Sin (2010) adds that rigor and quality are essential components of phenomenographic research. The hallmarks of high quality qualitative studies should: (a) be rich substantive accounts with strong evidence and (b) provide meaningful accounts for inferences and conclusions (Cohen & Crabtree, 2008).

Table 4. 1 Factors that Contribute to Trustworthiness in Phenomenographic Research

Researcher	Data
1. Acknowledge researcher's background and how it might impact data portrayal 2. Researcher should clearly state characteristics of participants 3. Approach data with an open mind 4. Account for the process to control and check interpretations 5. Member checking	1. Unbiased data 2. Describe the data analysis process 3. Present data 4. Thick description 5. Describe fully categories of description with quotes 6. Transferability

Note: Both researcher the data play a role in ensuring the trustworthiness of the research.

Trustworthiness, as outlined by Guba (1981), adds rigor to qualitative studies and refers to the applicability, consistency, neutrality, truth, and value of the study. Specific criteria for assessing and improving trustworthiness in this study are: (a) member checking, (b) thick description, (c) an open mind in approaching data, (d) an acknowledgement of the researcher's background, and (e) transferability. Member checking is one technique used in qualitative research to improve the validity of research findings, where participants have access to what has been made of their experiences so that they can be validated (Guba & Lincoln, 1994; Sandelowski, 1993). Creswell (1998) added that member checking is a way to add credibility to qualitative research as the researcher seeks to solicit the participants' view on findings and interpretations. To maintain trustworthiness in this research I used member checking. All individual

interview transcripts were returned to the interviewees who ascertained that their views were adequately presented. The teacher-participants read transcripts to determine whether I represented accurately their understanding and experiences with self-directed professional development.

Scott and Morrison (2007) proposed that qualitative research should be transferable. Regarding transferability in research, Guba and Lincoln (1994) stated that the researcher needs to provide a thick description of the setting, and the final judgment about whether the findings can be transferred is determined by the person seeking to make that transfer. Denzin (1989) described a thick description as more than the record of what the person is doing—it includes the significance of the experience. I provided a thick description by describing not only the experiences of the teacher-participants relating to self-directed professional development, but also data about the length of their careers as teachers, their love of mathematics, and the grade levels they taught. My goal was to provide additional information so that the reader could understand the teacher-participants' context. To further add to the trustworthiness of the data, three researchers read the interview data to corroborate the themes and the main ideas emanating from the data.

In qualitative research, the goal is to allow the reader or the user of the findings to transfer to similar situations. Patton (2002) asserted that qualitative research is credible when there is evidence of "intellectual rigor, professional integrity, and methodological competence" (p. 570). Patton further stated that the qualitative researcher should return to the data repeatedly to ensure that the categories, explanations, and interpretations make

sense. I followed Patton's advice and repeatedly read the data to validate the findings and to determine through the transcripts teacher-participants' perception, engagement in and their understanding of self-directed professional development.

4.5 Limitations of Phenomenography

Limberg (2008) stated that in describing the variation of the phenomenon under study, a comprehensive view is presented. Phenomenography data is collected from listening to participants such as through interviews. One of the criticisms of phenomenographic research is that it does not account for context. One way of counteracting this issue is to "ensure that interviews are carried out in ways that inscribe the phenomenon understudy in situations or contexts that are familiar to the interviewees and where there is basis for mutual understanding in the researcher-participant relationship" (p. 615). In addition, the issue of context can be considered by looking at examples of phenomenographic studies "conducted in relation to actual processes or situations where interviewees have been involved during the investigation" (p. 615).

4.6 Data Collection Instruments

4.6.1 Individual interviews.

Data collection is central to answering questions that frame research studies. In phenomenographic research, this process uses interviews (Jones & Asensio, 2001). Individual and focus group interviews were the instruments used for data collection in this study. The individual interview allows the interviewer to delve deeply into social and personal matters, whereas the group interview allows interviewers to get a wider

range of experience but, because of the public nature of the process, prevents delving as deeply into the individual experiences. Group interviews often take the form of focus groups, with multiple participants sharing their knowledge or experience about a specific subject (Di-Cicco-Bloom & Crabtree, 2006).

Qualitative interviews are a means for participants to reflect on and identify ways in which the phenomenon is experienced. There is no order to the questions nor is the wording precise (Merriam, 2009). This format allows the researcher to respond to the situation at hand, to the emerging worldview of the respondent, and to new ideas on the topic. In this way, the various responses sought in the study are shaped through the interview for further analysis by the researcher (Merriam, 2009). Recording and analysis of the data is done simultaneously, following the constant comparative method, so that the interpretations can be assimilated together. Ashworth and Lucas (2000) claimed that the main criterion for making judgments about an interview is whether it gives access to the participants' lifeworld. The interviews provided the data as teacher-participants responded to interview questions about how they perceive, engage in and understand their experiences with self-directed professional development in elementary mathematics education.

Scott and Morrison (2007) added that in using interviews, the interviewees are actively constructing their own worlds and the interviewer uses the text to develop insights into such worlds. In addition, Scott and Morrison explained that during the interview process both the interviewee and the interviewer are constructing meaning.

My assumption in this research was that teachers who self-identified as engaging in self-directed professional development would share in the interviews their experiences of professional development. By using interviews, I was able to access teacher-participants' professed reality and subjective experiences of self-directed professional development. Semi-structured interviews were used to understand how teachers perceive, engage in and understand self-directed professional development in mathematics education. Marton and Booth (1997) stated that phenomenographic studies typically describe the phenomenon through the inferences or reports of the subjects or participants. These reports are obtained in semi-structured, individual oral interviews using open-ended questions (Richardson, 1999). Interviews encourage interviewees to answer questions on their own terms and to seek in depth understandings from a sample of people, frequently purposively (Scott & Morrison, 2007).

This purposeful selection of individuals who share a common experience can be a rich source of data as they share certain common views on the phenomenon in question. Teachers who responded positively to participate in the research were encouraged to suggest other teachers who were actively engaged in self-directed professional development. Individuals discussed and explained how self-directed professional development in elementary mathematics education influenced them individually and collectively. Patton (2002a) underscored the importance of feeling questions, knowledge questions, and background and demographic questions while emphasizing that informed consent and confidentiality are protocols that must be discussed and maintained before interviews begin. Bloomberg and Volpe (2012) added that the exact words of participants should be recorded. I followed that convention in this investigation. The

data collected were coded and evaluated for themes and categories that emerged. Teacher-participants were given opportunities to clarify their views several times during the interview and to correct the researcher where necessary to ensure that their views were not misrepresented or misunderstood. The individual interviews were conducted during the school term at teacher-participants' convenience.

Two features of a phenomenographic interviews were followed in this research: (a) the interviews were directed towards the phenomenon, that is, the questions were on self-directed professional development in elementary mathematics education and (b) the interview questions were broad enough so that teacher-participants could provide meaningful responses without forcing a structure upon the interviewees (Bruce et al., 2004). After the interviews were transcribed, they were sent to the individual teacher-participants to ensure that their ideas were correctly represented. Member Check (Creswell, 1998) was done to ensure that teacher-participant perceptions were accurately portrayed in individual interview questions (see Appendix E for the individual interview questions).

4.6.2 Focus group interview (FGI)

I used a focus group interview to collect data in addition to the individual interviews which facilitated triangulation. Scott and Morrison (2007) stated that focus groups are important because the collective activity provides the framework for interaction. The use of focus groups provides researchers with important insights into research questions through participant discussion and interaction (Morgan, 1997).

Patton (2002b) added that it is advantageous to use focus groups in qualitative studies for several reasons: (a) interactions among participants enhance data quality as participants tend to provide checks and balances on each other, which weeds out false or extreme views, (b) the extent to which there is relatively consistent, shared view or great diversity of views can be quickly assessed, and (c) focus groups tend to be enjoyable to participants. In the Focus Group Interview (FGI) I conducted for this study, teacher-participants shared and clarified their understandings of self-directed professional development. Teacher-participants' views were clearly presented and accounts of their understanding and experiences with self-directed professional development were discussed. As teacher-participants shared in the discussions, general themes and ideas came to the fore about their perceptions, engagement and understanding of the role of self-directed professional development in mathematics education.

One of the purposes of the focus group is to observe the interaction among participants, which produces insights and data that most likely could not be obtained from individual interviews. Participants should benefit from the discussion (Connelly, 2015; Morgan, 1997; Scott & Morrison, 2007). All the teacher-participants in the focus group had one thing in common. They were all elementary teachers who said they engaged in self-directed professional development. In addition, it was obvious to me, based on participants' engagement and dispositions in the discussions that they enjoyed teaching elementary mathematics. Commonality of experience among participants allowed them to engage in deep conversations about their understanding of self-directed professional development on their professional lives and their practice (Connelly, 2015). I analyzed the data from the focus group session and compared them with the data from the

individual interviews to determine the categories of descriptions. In focus group interviews, the teacher-participants provided context and perspective that enabled their experiences to be understood holistically (Carey & Asbury, 2012).

4.7 Data Analysis

The data analysis procedure began with transcribing verbatim the recorded individual and focus group interviews. I then read the transcripts several times as I tried to find and code meanings from the teacher-participants' responses to the data collection questions. As outlined by Akerlind (2008) when speaking of phenomenographic data analysis, I compared excerpts from different interviews, searched for similarities, differences, and peculiarities among the teacher-participants' responses to the questions and among a teacher-participants' response to different questions during the individual and group interviews. After coding the data, I grouped the codes and the subsequent themes that emerged, as I looked for relationships among them.

Phenomenographic data analysis process begins with a selection process. This selection is based on relevance, selecting statements of relevance to make up the data pool where statements that are of interest to the question being studied are selected and marked and these make up the data pool (Akerlind, 2012). The selected quotes or statements form the basis for the next step where the researcher determines the meanings embedded in the quotes. I brought statements together that were similar and separated some statements because of their differences. The categories of description that emerged from the data determined the outcome space. Swensson (2006) stated that the category is a description of what is the "common meaning of the phenomenon grouped together" (p.

168). Kilinc and Aydin (2013) claimed that in phenomenography the descriptions given by individuals play a primary role in determining the outcome space. The researcher should clearly understand individuals' descriptions to categorize the descriptions arising from the data, as the primary goal is to ascertain the frameworks within which various categories of understanding exist.

Through the iterative process of reading and coding and categorizing the codes into broader themes, I analyzed the data. I borrowed grounded theory analytic strategies to complement phenomenographic analytic strategies when analyzing the data. Grounded theory strategies for analyzing data are usually associated with issues that affect the lives of individuals (Chamaz, 2008; Glaser, 1978; Glaser & Strauss, 1967; Strauss & Corbin, 1998). Grounded theory analysis, although critiqued for their positivistic origin, offer an inductive approach to analyzing data as well offer a goal to generate models and emergent theories (Chamaz, 2008). Chamaz further asserted that since the researcher and the researched co-construct the data, it is important to consider researcher positionality, which I outlined below. Grounded theory methods as outlined by Chamaz (2008) helped me to analyze the data. I used axial and selective coding (Walker & Myrick, 2006) to further identify the distinct categories that emerged among the codes and by using axial coding, I identified the relationships and the connection that were evident between the responses. Selective coding was done by rereading the transcripts and identifying the core themes in teachers' responses.

Merriam (2009) stated that it is important to make sense of the data by consolidating, reducing, and interpreting what people have experienced. In addition,

what the researcher has seen and read are also involved in the meaning construction of the research (Merriam, 2009). I performed the data analysis process to conform to procedures identified by Akerlind (2008). By using both the individual interviews and the FGI, I was able to corroborate the data. I began my data analysis by reading teacher-participant's responses to the individual interview questions. The individual transcripts were read repeatedly to identify similarities, differences, and peculiarities in teacher-participant responses and to identify words or phrases that indicated how teacher-participants perceived, engaged in, and understood self-directed professional development. I then read all the responses to the first question on the interview and continued this process for all interview questions. I followed the same procedure with the FGI. The teacher-participants' descriptions were further classified as I looked for emergent themes. The data analysis focused on identifying meanings that were evident from the transcripts and not from pre-determined categories (Goh, 2013).

I highlighted and made notes about the similarities in teacher-participants' responses using different colors and identified several themes. Repeating this procedure, I ensured that the themes were relevant. I used data analysis practices pertaining to grounded theory in conjunction with phenomenographic practices as both phenomenography and grounded theory seek to understand the realities of a phenomenon. Strauss and Corbin (1990) identified open coding as one of the three basic types of coding in grounded theory research. I used open coding to identify similarities and differences in teacher-participants' responses. After the initial coding and recoding of data, I identified and categorized emergent themes. In the data analysis I also used selective coding procedures as described by Corbin and Strauss (1990). Selective coding,

which occurred toward the end of the analysis, is the process by which I refined and defined categories as they captured the meaning of the teacher-participants. After I determined the categories, I identified an outcome consisting of five interrelated conceptions. Figure 4.2 represents the data collection and analysis process that resulted in the outcome space.

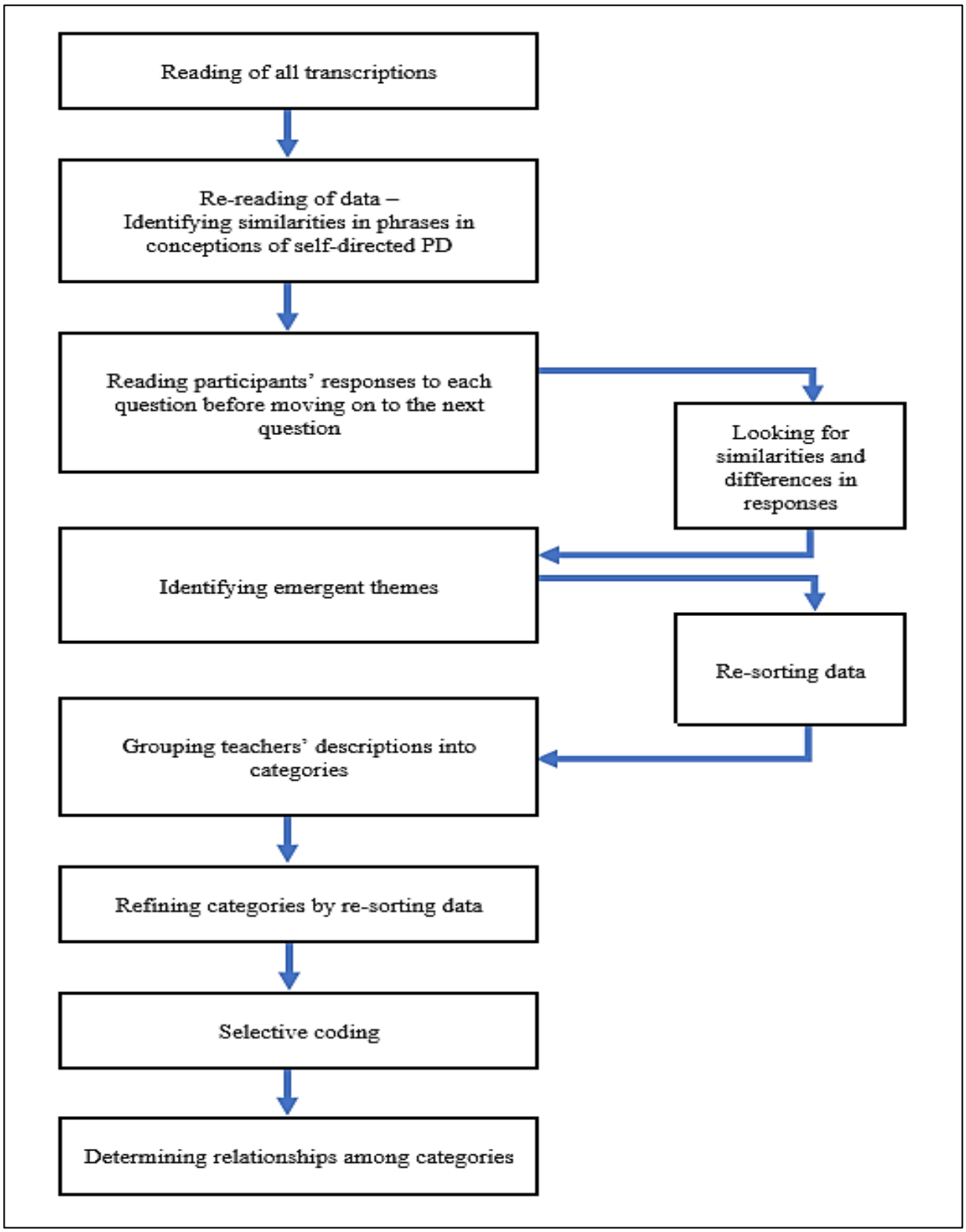

Figure 4. 2 Visual representation of phenomenographic analysis

4.8 Ethical Considerations

I followed ethical considerations as outlined by the Ethical Review Board of this University.. Approval of the proposal and ethics preceded the invitation to participate in this study (see Appendix F). Teacher-participants received a letter of information about the investigation that they read before agreeing to participate in the study (see Appendix A). A letter of information was also given to each participant (Appendix B). Consent forms were signed, collected, and safely stored before teacher-participants were interviewed (see Appendix C). The teacher-participants were informed of the purpose and goals of the study and about the confidentiality of their responses before the interviews were conducted (see Appendices D and E for individual and focus group interview). Ethical approval from the university preceded all activities before the research was conducted (See Appendix F).

4.9 Participant Selection

The teacher-participants in this investigation identified themselves as engaging in self-directed professional development activities in elementary mathematics education. This base group of teacher-participants provided data for this investigation through interviews and a focus group session. Letters of invitation to participate in the research were sent to and through the administrators of professional teacher organizations like the Ontario Association for Mathematics Education (OAME), and through the Faculty of Education, Master of Professional Education Program (MPEd) at a university in Ontario. and through my supervisory committee (see Appendix A for the Letter of Information). In addition, invitations were sent through my supervisory committee and through the

Teacher Education Program to students who were completing Additional Qualification (AQ) courses at the Faculty of Education at the same university.

This investigation utilized purposive or theoretical sampling procedures. Guba and Lincoln (1994) agreed that purposive or theoretical sampling is useful in qualitative research as it increases the range of data collected with the chance that multiple realities will be uncovered. Purposive sampling strategies are designed to enhance understandings of selected individuals or groups' experience(s) or for developing theories or concepts. Patton (2002a, 2002b) maintained that purposive sampling is aimed at insight about the phenomenon and not empirical generalization from the sample to the population. Researchers seek to accomplish purposive sampling select "information rich cases—individuals, groups, organizations, or behaviours that provide the greatest insight into the research question" (Devers & Frankel, 2000, p. 264). The teacher-participants in this study reflected an information rich sample, as they were all active participants in self-directed professional development activities in Ontario.

4.9.1 Participants

The study consisted of a population of 10 teachers working in public schools in the province of Ontario who self-identified as being involved in self-directed professional development. Teacher-participants teaching careers spanned from six to more than 25 years of teaching. Participants worked in different school boards but had one thing in common: they all expressed a positive attitude towards teaching mathematics and towards students' success in mathematics. Individual and focus group interviews were conducted at the convenience of the teacher-participants. All 10 teacher-participants said

they were active participants in professional development activities at their schools. Demographic information about the teacher-participants identified the grades they have taught and the length of their teaching careers.

Table 4. 2 Demographic Data of the Sample

Name (Pseudonym)	Years taught	Grades taught	Attitude toward teaching mathematics
Gary	25 and over	1-8	Positive
Harry	10 – 14	1-8	Positive
Ivan	10 – 14	3, 4, 5, 6	Positive
Jonathan	10 – 14	K-8	Positive
Abbey	10 – 14	2, 4, 5, 6, 7, 8	Positive
Barbara	10 – 15	1, 2, 3, 5, 8, 9, 11, 12	Positive
Pamela	5 – 10	6, 7, 8	Positive
Donna	15 – 20	3, 4, 5, 6, 7	Positive
Fay	25 and over	K, 1, 2, 4, 5, 6, 7, 8	Positive
Edna	10 – 14	2, 3, 4, 7	Positive

Note: Teacher-participants have teaching experience across all grade levels.

The sample used in this research consisted of four male and six female teachers who had taught grades from Kindergarten to Grade 12. In Table 4.2, I provide demographic data of the participants in this research investigation. The average number of years taught by the teacher-participants is 14.3. Teacher-participants shared the following commonalities:

- All were qualified teachers
- All had completed a bachelor's degree in education as their minimum qualification

- All were working in publicly funded schools
- All were teaching mathematics to elementary grade students
- All indicated a positive attitude towards mathematics teaching.
- All were certified by the Ontario College of Teachers (OCT)

The vast difference in professional experience enhanced the diversity of the population.

4.10 Researcher's Position and Reflexivity

Research projects are usually of personal interest to the researcher and this influences the researcher's stance on certain issues. The positions I have held as a teacher in public and private schools and as a student in higher education served to inform my research, and formed the basis of my assumptions and perspectives on teaching and learning. Creswell (1998) stated that it is important for a researcher to begin the data analysis by describing a personal relationship with the phenomenon in question. This is called bracketing or reflexivity and is inherent in qualitative studies (Creswell, 1998; Fine, 1994; Macbeth 2001). All researchers have biases. At the conceptualization stage of the study, my biases were important in shaping my ontological views. While biases may shape one's ontological views, the experiences of the participants provide the data for the research. Since researcher bias plays a role in research, Fine (1994) advocated that it is important to "work the hyphen", meaning that the researcher and the participants should discuss what is happening "between them, identify the boundaries and determine for whom and why the story is being told" (p. 135).

In explaining reflexivity, Scott and Morrison (2007) stated, “it is the process by which the researcher comes to understand how they are positioned in relation to the knowledge they are producing, and indeed, is an essential part of that knowledge producing activity” (p. 202). During this investigation, I was cognizant of my positions in relation to this research. I was aware of my own biases based on, for example, my past experiences as a classroom teacher who had experiences with self-directed professional development. Reflexivity allows the researcher to provide an avenue for clarity in terms of the researcher’s role as there are “tensions embedded in one’s positions” (Hamdan, 2009, p. 337). If reflexivity is “researching one’s self and reflecting on personal beliefs and value both as a researcher and as a member of the researched group” (Hamdan, 2009, p. 377), then it is important for me to state my views. I presented the stories of the teacher-participants without highlighting my experiences and my views about self-directed professional development; I bracketed my views about self-directed professional development and used only the reported statements of the teacher-participants. In conducting the interviews, I bracketed my views, in that I did not allow them to prejudice how I related what the teachers shared about their perception, engagement and understanding of self-directed professional development. However, while interpreting the data, my beliefs, assumptions and experiences helped to shape how I analyzed and interpreted the data. Throughout the data analysis and interpretation stages of this research, I shelved my preconceived notions about self-directed professional development and allowed the data to tell the story. This notion of setting aside pre-judgments or bracketing are essential in research where one examines or explores the experiences of others (Allen-Collinson, 2011; Creswell, 1998).

I am a PhD candidate with over fifteen years' teaching experience at the K-9 level. The positions I have held at educational institutions include secretary for the staff association, coordinator for Grades 4 and 6, leader for a teacher study group, and a marker for Grade 6 national exams in two countries where I have lived and worked. My research interests include professional development of teachers, teacher identity, adult learning, and elementary education. As a researcher who has experienced self-directed professional development, I have hunches on some factors that may lead teachers to engage in these activities. These hunches include teachers' need for self-actualization, teachers' interest in the subject, and their need to develop their knowledge in the subject and its teaching

4.11 Mathematics Education and Phenomenography

Phenomenography has been used in educational research to study variations in conceptions. Several studies investigated the variations in individuals' conceptions (Case & Light, 2011; Entwistle, 1997; Gardner, 2007; Goh, 2013; Limberg, 2008). In mathematics education, research was conducted to investigate students' conceptions of mathematics (Kotecha, 2002; Neuman, 1997; Reid, Petocz, Smith, Wood, & Dortins, 2003), and also the professional development of mathematics teachers (Attorps, 2003; Rogers et al., 2007; Simon & Schifter, 1991), including mathematics teachers in higher education (Biggs & Tang, 2007). Kotecha (2002) also examined students' understanding of problem solving using phenomenography. Kilinc and Aydin (2013) and Kyriakides (2009), respectively, used phenomenography to understand teachers' understandings of sustainable development and the complexity of learning fractions. The findings of these

studies indicate that phenomenography is useful both to determine how students explain and understand their own learning and to understand variation among individuals. Researchers also used phenomenography in mathematics education to look at a worldwide concern that schools must change to meet the rapidly changing demographics because of globalization and technological and cultural changes (Lieberman & Mace, 2010).

4.12 Chapter Summary

In this chapter, I introduced the reader to the methodological approach and the design of this study using the qualitative approach of phenomenography. This qualitative approach used individual and focus group interviews as the data collection instruments. Phenomenographic data supported by grounded theory analysis involved an iterative process of reading, rereading, coding, recoding, identifying emergent themes, and establishing categories of description. In recognition that trustworthiness is important in phenomenographic research, I outlined how this research is trustworthy by stating clearly the procedures involved in the data collection and the analysis process, including outlining my position as the researcher.

Chapter 5

Research Findings

5.0 Introduction

The overarching question guiding this research is: How do elementary teachers *perceive*, *engage in*, and *understand the role* of self-directed professional development (PD) in elementary mathematics education? The specific questions that frame this research are:

Research question 1 (RQ1): What is the nature and role of the self-directed professional development and how do teachers describe self-directed professional development in their mathematics practice?

Research question 2 (RQ2): What are the factors and teacher characteristics, if any, that lead to self-directed professional development among elementary teachers?

Research question 3 (RQ3): What are the conditions, if any, that support teachers' involvement in self-directed professional development?

Research question 4 (RQ4): To what extent is self-directed professional development transformational?

Research question 5 (RQ5): What are the variations of experience reported by teachers who engage in self-directed professional development?

This chapter is organized chronologically by research questions.

5.1 Analyzing the Data

I analyzed the semi-structured individual interviews and the Focus Group Interview (FGI) sequentially, in a similar manner to sequential mixed strategies design. I coded the data collected from the interview and analyzed it for emergent themes. Next, I used the same procedure to for the data collected from the focus group interview. The individual interview consisted of 12 questions of which the first four were related to demographic data about teaching experience and the grades taught. The succeeding eight questions asked teacher-participants to reflect on their experiences with self-directed professional development. The excerpts I use in this chapter are drawn from both the individual interviews and the FGI.

The FGI consisted of seven questions that focused on teacher-participants' experiences with self-directed professional development. The FGI began with teacher-participants introducing themselves to each other. This was done to create an atmosphere of collegiality and for teacher-participants to feel at ease and be comfortable with each other. This objective was achieved as the teacher-participants conversed freely and amicably with each other, discovering commonalities among themselves. These commonalities were in part related to their interest in and love for teaching mathematics.

The first question on the FGI was: If you were asked to define self-directed professional development, what would your definition be? The eleventh question on the individual interview asked: What would you like stakeholders to know about self-directed professional development in elementary mathematics education? These two questions are unique, and I treated them in a different manner. I reported all the

responses to these questions so that the readers could get a comprehensive view of teacher-participants' understanding of self-directed professional development. For the other questions, I reported on the responses that exemplified a theme. I discuss the responses to RQ5 in Chapter 6 as the question relates to the variation of teacher-participants' experiences in self-directed professional development.

Another unique feature I observed between FGI and individual interview was that at the FGI the teacher-participants' responses were much shorter than during the individual interviews. This was partly because in the FGI teacher-participants tended to indicate agreement (or, rarely, disagreement) with the responses given earlier on the same question. In presenting the data, I have grouped together the individual interview and FGI questions that were related to the research questions. The responses of the teacher-participants that were pertinent to the specific research question are presented and pseudonyms are given to the respondents.

5.2 Nature of Self-Directed Professional Development (RQ1)

To understand the nature of self-directed professional development, I sought to explore teacher-participants' understanding and perception of the phenomenon. Since this study focused on self-directed professional development, it was important to understand how teacher-participants' understanding and if there were variations in their conceptions. Accordingly, in explaining their understanding of the nature of self-directed professional development in which they engaged in, teacher-participants shared what it meant to them.

5.2.1 What is the nature and role of self-directed professional development?

The interview question that focused on the nature of self-directed professional development was: What is the nature of self-directed professional development and how do teachers describe self-directed professional development in their mathematics practice? To understand the nature of self-directed professional development, I asked teacher-participants in the focus group and individual interview to share their understanding of self-directed professional development. This was done to provide a context in which teacher-participants engage in professional development. In the focus group interview, I shared my understanding of the concept of self-directed professional development as a learning activity done by teachers that is not mandated by the MOE, school boards, or administrators. I then asked the teacher-participants to share their understandings of self-directed professional development to generate a discussion on its context, the need for the concept, and its applicability to their practice.

Self-directed professional development as used in this study is "professional development arising from the teachers' own initiative" (Mushayikwa & Lubben, 2009, p. 37). Four of the teacher-participants present at the FGI shared similar understandings. The similarities that were evident in the teacher-participants' understanding of self-directed professional development related to: (a) the desire to meet students' needs, (b) having choices to make, (c) being curious, and (d) pursuing one's interest and participating in professional development that was not mandated and finding answers to one's questions.

5.2.2 Understandings of self-directed professional development.

The following excerpts reflect teacher-participants' understandings of self-directed professional development. I asked teacher-participants about their understanding of self-directed professional development. Four teacher-participants responded. The other teacher-participants present confirmed their understanding by agreeing with the previous responses. Gary, who had taught for over 20 years and described himself as a perfectionist, believed that the teacher's performance in the classroom is important. In explaining his understanding of self-directed professional development, he hinted at the need to be a better teacher.

> I would define self-directed PD as what I need personally *to teach my students better*. Currently, what I am looking at right now is brain research and how the brain operates… How we can foster those things and how that can improve learning. I get to choose it because *it is directly related to what my students need*. So, I'm going directly to the class. They need it *so I need to learn it,* as opposed to everybody needs to do it. [emphasis added]

Gary's definition suggests that self-directed PD fulfills a need to be engaged in activities that are directly related to the needs of his students and to facilitate better teaching skills with the possible goal of improving students' learning. Similar to Gary, Edna, who described herself as a math specialist with fourteen years' experience teaching at the elementary level, included the notion of choosing to learn something to benefit her students.

> Self-directed learning (PD) would *be learning I choose* and it would either come out of some *observation I made in my students*... There is obviously a weakness here and I need to learn more... It's *that curiosity* that has bubbled up in me and it's something I want to follow. And *it's not mandated by anyone* else. It's just the *curiosity* of something I want to learn more about. [emphasis added]

Edna mentioned the idea of personal choice. Her understanding included the notion that students can inspire self-directed PD. This is evident in her statement that based on her observation of her students' learning, identifying a weakness created a desire in her to learn more to help her students. Another feature of her understanding was that self-directed professional development is not compulsory, as neither school boards nor the MOE mandate it. Rather, it is learning that the teacher chooses. It is motivated by the teacher's desire to learn more about a topic relevant to her and/or her students. Edna also recognized curiosity as a motivating factor that led to engagement in self-directed PD. Abbey, a curious and reflective teacher who had taught for 10 years, explained her understanding of self-directed PD and identified curiosity as a major factor.

> I absolutely agree with Edna. I think it is very *much based on curiosity* and for me it's where the curiosity comes from. It could be interactions in the class. It could be *stemming from collaboration* with other teachers or just out of *your own interest from different experiences*. So, I definitely agree that self-directed PD comes out of *your own curiosity* and its propelled by yourself and fueled by others. [emphasis added]

Abbey's understanding of self-directed PD indicated that curiosity is an important part of wanting to be engaged in self-directed PD. This curiosity, she stated, may arise from different situations including interactions with her students while teaching, collaboration with colleagues, or simply one's personal interest from different experiences. An added dimension to her understanding of self-directed PD was the notion of answering one's questions, a view shared by Donna. Donna, a teacher of ten years who had a special interest in the history of mathematics, stated clearly that self-directed PD is the ability to be involved in research activities that help to get answers to questions.

> I would define self-directed PD as whatever research I'm doing *to answer my own questions*. It is not professional development that I am sent to or forced to do. *I have my own questions*. I can find the *actual venue (way) to answer them*. [emphasis added]

To Donna, self-directed PD is about getting answers to her questions and doing so on her own. There were similarities in the teacher-participants' conception of the term self-directed professional development. Teacher-participants' conceptions or understandings included ideas relating to needing to teach students better (Gary), facilitating learning, choosing to learn based on observation of students' needs, being curious about something (Edna & Harry), and seeking to answer one's questions (Carol). This understanding highlights the view expressed by other teacher-participants during the individual interviews and the FGI that self-directed PD is personally motivated—it is done because of teachers' personal interest. Teacher-participants' understanding of self-directed PD indicated an interest in facilitating their own learning and that of their students.

5.2.3 Role of self-directed professional development.

At the FGI, I specifically asked teacher-participants: What do you see as the role of self-directed professional development in elementary mathematics education today? This question was asked to determine whether teacher-participants perceived that there was a role for this form of professional development in mathematics education. This question also asked teacher-participants to speak to the role, if any, self-directed PD played in their professional learning in mathematics education.

Abbey highlighted that while self-directed PD played a role in elementary mathematics education, this role changes and was influenced by factors such as the grade level being taught and the curriculum.

> I think the role changes from year to year. This year I was working on a special project with many teachers, where we are looking at the curriculum. My math self-directed PD is a result of moving from one grade to another. I had to *grapple with the content and figure out my pedagogy*. The amount of PD (self-directed) required depended on my comfort with the curriculum as well. [emphasis added]

For Abbey, the role was dependent on the grade she was teaching, the new content she had to get familiar with, and the level of comfort (or discomfort) she felt with the curriculum, particularly after transitioning to teach a new grade. On the other hand, Donna, who had enjoyed teaching for the past 10 years, added that since "board sanctioned professional development" is not differentiated, "all [*sic*] the PD that I do is

self-directed." Donna further qualified this statement by adding that her "professional development is now all self-directed as she asks her own questions, *gets her own answers wherever she can find them* [emphasis added]."

In response to the same question, Fay, who had over 25 years' experience in the teaching profession, described herself as a perfectionist. She clarified her conceptions of self-directed PD and equated it with what she termed independent professional development, which she stressed was important in keeping her practice current.

> I think professional development is very important because I find that it keeps me *current with what's going on in mathematics pedagogy*. I know that Math Talk is big right now. What I do is I just take the initiative on myself and try to use resources [mathematics] that are being recommended, or I get a hold of teachers' manuals or resource books. During my own time at home I go through these things. I look *on the internet*. I am always looking for *new ideas to make my lessons more meaningful for kids*. And then, after I'm done, I take and I look at what the kids have done, and I try to use that *to direct my thinking.* [emphasis added]

Fay, in describing the role that self-directed PD plays in mathematics education, attributed it to allowing her to engage with mathematics pedagogy that is of current interest. Edna echoed some of the views shared by Fay and added that from her perspective self-directed PD is a better way to customize professional development to meet teachers' needs. She described self-directed PD as "personalizing for the educator."

Edna proposed that teachers should participate in professional development activities that fulfill personal needs. The teacher-participants' responses indicate that they are actively engaging in activities that result in their learning and improving their practice in the classroom.

The roles that self-directed PD fulfilled in the lives of teacher-participants relating to their professional development were important as they (a) had opportunities to familiarize themselves with content, (b) got answers to questions, (c) participated in professional development that catered to their individual needs, (d) made mathematics meaningful to children, and (e) kept current with mathematics pedagogy. The roles played by self-directed PD functioned as learning experiences for teachers.

5.2.4 Self-directed professional development activities.

In the individual interviews, I also asked teacher-participants to describe what self-directed professional development looked like to them. I encouraged them to identify the different ways in which they engaged in self-directed professional development activities. I asked: What does self-directed professional development look like for you? and what activities in mathematics education do you engage in that are considered self-directed? Teacher-participants identified many self-directed professional development activities that were categorized as Internet-based, individualized, and collaborative. These activities included participating in Twitter chats, reading resource books written by mathematics educators, and participating in action research with other teachers.

Ivan, who had taught for 10 years and who liked to share his mathematics learning with others, stated that he engaged in self-directed PD in several ways. He was actively engaged in Twitter chats and participated in board-sanctioned learning activities.

> I participate in *Twitter chats* around good and best practices for teaching mathematics right here in Ontario. I am involved in *Teacher Learning and Leadership Program (TLLP) groups* to align best practices with colleagues in my *district here* in respect to teaching mathematics and literacy and as well as working on *my masters in mathematics* has really opened my eyes to some of the resources that are available. [emphasis added]

The use of Twitter, action research with colleagues, board-level collaborations, and graduate studies are the ways in which Ivan engaged in self-directed PD. Abbey, like Ivan, similarly engaged in self-directed PD through Twitter and board-level collaborations, but she also engaged through blogging, school-level collaboration, and attending conferences:

> I spend a lot of time on *Twitter* like being connected to educators so that's been part of it. *Attending conferences* when I can. I guess it started just by getting involved at things *at the school level* and then from there just being a part of *more board* activities and *definitely on my own*. It's reading, I do a lot on *Twitter*, *following blogs* and those type of things that keep me going. It's nice to see what other teachers are doing as well. I find that really helps. [emphasis added]

Barbara, a teacher for 15 years who was interested in how students think, participated in action research with colleagues. She mentioned Additional Qualification (AQ) courses and specified, as did Ivan, action research projects she engaged in with the TLLP as well as ETFO courses, along with province-wide activities.

> A couple of different things besides the *AQ courses* that I have taken, I have also been involved with *action research,* so I've been involved with Teacher Learning and Leadership Program (TLLP). I have also been involved in some *action research* through the *ETFO* called the Teachers Learning Together and The Math Journey. I think that is what they called it. It was also action research in math. In addition, whenever there are courses advertised through ETFO so sometimes if a course comes up that looks interesting, I will enroll in the course. [emphasis added]

Barbara's self-directed PD activities were varied as she worked on projects with other teachers and took courses. Fay engaged in self-directed professional development through reading PD resources as well as accessing lesson plans on specific topics:

> I look for *lesson plans that involve manipulatives*. I do reading. Right now, *am reading books by mathematics educators*. I will try to identify current *professional development resources* that are recommended. I will try to get my hands on them, I'll ask the school principal to buy them for the school library, and then I'll borrow them, take them home,

> read them and make notes and record activities that I think will be good. [emphasis added]

In addition to reading and recommending books for the school's library for teachers, Fay engaged in self-directed PD when she accessed lesson plans on a specific way of teaching. In her quest to make mathematics learning more meaningful to her students, Fay searched for resources related to the teaching of mathematics using manipulatives. She also reported that her school had a high English as a Second Language (ESL) population. To make mathematics learning relevant to these students she was reading a book on how to teach ESL mathematics.

Elementary teachers are choosing to participate in their professional growth and development by engaging in many different learning activities. Some of the main activities that teachers participate in for self-directed professional development are presented in Table 5.1. It is noteworthy that each teacher-participant engaged in at least four of the activities identified. The diverse activities identified by teachers suggest that teachers are individually selecting self-directed PD activities and that they have choices in the different types of activities that they select. In addition, teachers are not waiting on schools to provide professional development activities for them. Rather, teachers are making professional judgments about their learning needs and are addressing them through self-directed PD.

Table 5. 1 Self-Directed Professional Development Activities

Internet Based	Individualized	Collaborative
Twitter	Reading Research Papers	Attending Conferences
Writing and reading blogs	Reading mathematics resource books	Conducting action research with colleagues
Internet searches for lesson plans	Reading books by mathematics educators	Board level collaborations
Accessing websites for math and technology	Pursuing masters' degrees	Teacher learning and leadership program
	Completing AQ courses	

Note: The activities in the last row may serve other purposes than self-directed professional development.

I classified teacher-participants' self-directed professional development activities into three categories. Table 5.1 indicates that teacher-participants' activities are Internet-based, individualized, and collaborative. These different avenues used by teacher-participants to foster their professional growth through self-directed professional development indicate that teacher-participants embraced a variety of opportunities to learn in mathematics education. Although the main motivation for the teacher-participants to engage in these activities was self-directed professional development, the activities identified in the last row also offer other opportunities, other than professional learning, such as access to promotion to leadership roles.

5.2.5 Motivation for engagement in self-directed professional development.

In addition to explaining the role of and sharing the self-directed PD activities they engaged in, teachers were also asked in the individual interviews, what prompted

them to become involved in self-directed PD. The responses they gave indicated that self-directed professional development was an avenue for teacher-participants to share their learning, to learn new content, to become more proficient, to improve their teaching practice, and to foster personal and professional growth. Barbara identified the ability to know more about mathematics and to use the best practices in mathematics teaching as reasons for her engagement in self-directed PD.

> I think I wanted to become *more knowledgeable and be more current* with my teaching practices in math. After teaching for 15 years, the PD that we have received, at least in the schools that I have worked in, have not been focused on math. It has been mostly literacy and I want to add *math is a subject that I really enjoy, and I wanted to become more proficient in teaching it.* [emphasis added]

Barbara's engagement in self-directed PD was mainly because she wanted to be more knowledgeable as well as more proficient at teaching mathematics, as she had observed that not much of the mandated PD she had received was focused on mathematics teaching. Harry, who had taught for 14 years and who experimented with inquiry-based learning, shared that for him self-directed PD was mainly improving his mathematics content knowledge.

> For me at this stage PD is when you *learn the content* with mathematics as a subject. My last PD was 3 and a *half years when I pursued my Master's degree. I needed more mathematics. I needed to understand*

> *what happens. I wanted to have the whole picture of the subject.* [emphasis added]

Harry engaged in graduate studies as a self-directed PD activity and was curious about mathematics. Carol, who had been teaching for six years, said she was driven to self-directed professional development because of "desperation, because I did French history and I have no *practical experience in terms of learning how to teach mathematics*. *I had to learn* so that I could not to mess up with my kids [emphasis added]."

In these responses, teacher-participants gave different reasons for their motivation towards self-directed professional development. For Barbara, it was a need to be current in mathematics practice and to be more knowledgeable in the subject, whereas for Harry the motivation was to learn mathematics content. Carol, who was excited about teaching mathematics, stated that her involvement in self-directed professional development activities was a result of a feeling of desperation, as she did not want to impede students' mathematics learning because of her lack of experience in teaching elementary mathematics.

While some teacher-participants indicated a need to learn, still others were driven to self-directed professional development because they were curious. A few teacher-participants stated that they had natural curiosity. "It's because I was curious." Fay added that a recognition that "I was not doing it (teaching mathematics) right and it led me to become involved in self-directed PD". Edna stated that her Bachelor of Education (BEd) program did not sufficiently prepare her for teaching so that led her to self-directed PD. Similarly, Barbara said "The board didn't have enough available for me to follow up

so that was also my motivation then. I feel like I want to offer the best experience and I want to be confident about my practice." Harry also shared that curiosity played a role.

> It stemmed out of my own curiosity and what is happening with my students at the time. It also goes back to my *internal curiosity* matched with my own personal pedagogy. What I would want for professional development five years ago would be different from what I am looking for now. [emphasis added]

He further clarified that he was tired of hearing what research said about teaching mathematics, so he was strategic in selecting courses and attending workshops that were geared towards improving his pedagogy and learning new strategies for teaching mathematics. Joe, who had taught for 10 years and enjoyed using technology, in response to the same question on motivation said, "I just want to be better at teaching. The more I want to learn, the more questions I have, the more research I have to do and I just keep pushing more and more."

For other teacher-participants, their interests led them to self-directed professional development. Ivan responded that the ability to share information excited him, so he enjoyed interacting and sharing with teachers. "I like being a member of *professional learning groups* and I like to bounce off ideas to *other like-minded people* [emphasis added]." He attributed his involvement in self-directed PD to his love of interacting with teachers. Abbey, however, was interested in learning based on her students' interests.

> I guess *my own interests and knowing what is best for my students.* I see that how students learn may be changing a little bit in different ways.

> They like to interact so it's important to see what is working for them [emphasis added].

Her students' interests played a pivotal role in her desire to engage in self-directed professional development.

Given the different responses from teacher-participants regarding the motivation for their engagement in self-directed professional development, it is evident that there is a cluster of factors that may lead teachers to this form of professional development. Some of the factors that led teacher-participants to be engaged in self-directed professional development included the need to be more: (a) knowledgeable in math content, (b) proficient, (c) confident, (d) deeply committed and alert to students' needs, and (e) focused on their professional growth. The high motivation levels for teacher-participants' involvement in self-directed PD was evident and indicates that their high valuation of professional learning through self-directed professional development and stemmed from their deep and abiding commitment to students.

5.2.6 Nature, role, and descriptions of self-directed professional development.

Teacher-participants' understanding of the nature, role, and description of activities associated with self-directed PD seem to indicate that it takes several different forms and that it performs varied roles. In explaining their understanding of self-directed PD, teacher-participants seemed to suggest that they were motivated to promote their

professional growth as well as to foster mathematical learning for their students. Self-directed PD is not mandatory; it is the teachers' choice to be engaged in such activities.

To the participants in the study, self-directed PD was seen to promote teacher learning to fulfill students' needs while at the same time providing teachers with professional learning opportunities. To the teacher-participants, self-directed PD is not limited to one format, as noted in Table 5.1. The self-directed PD activities highlighted by teacher-participants included (a) using Twitter and accessing websites for math and technology, (b) reading research papers and completing AQ courses, and (c) conducting action research with colleagues and participating in board level collaborations. From teacher-participants' responses, it is evident that self-directed PD is driven by teachers out of their curiosity, their need to learn, their wish to find answers to questions they have about an issue, their desire to participate in learning that is not forced, their need to help students learn better, and their desire to learn about something that is relevant to them. The type and form of self-directed PD that teachers participate in is dependent on their need and purposes. This need can be for promoting one's learning on a topic with the goal of enhancing learning for students. Students' needs also seemed to matter to teachers and played a major role in teachers' decision to become engaged in self-directed PD.

5.3 Teacher Characteristics (RQ2)

Another important aspect of this investigation on self-directed professional development was centered on the teacher-participants' characteristics. I wanted to find out if these elementary teacher-participants identified specific personal characteristics

that inclined them to be engaged in self-directed PD. The research question was: What are the factors and teacher characteristics, if any, that lead to self-directed professional development among elementary mathematics teachers? The essence of this question is that possibly there are certain personal characteristics identified by teachers that predispose them to be engaged in self-directed professional development. In the FGI, I asked teacher-participants: what have you learned about yourself as a teacher, because of your engagement in self-directed professional development? In the individual interviews I asked the teacher-participants to reflect on their experiences in self-directed professional development in mathematics education and to say what they had learned about themselves as teachers. They were further prompted with the following question: Can you identify any personal qualities that motivate you to be involved in self-directed PD in elementary mathematics education?

Gary, who had been teaching for over two decades, characterized himself as someone who seeks perfection and believes that performance is important.

> I am driven. I am *a perfectionist*. My background is important. I came through music. *Performance* is important. You know you are never going to be perfect so you give your best performance. [emphasis added]

Gary's desire to be perfect is the driving force behind his engagement in self-directed professional development. Abbey, on the other hand, identified other qualities that led her to be engaged in self-directed PD.

> I would say I am *curious myself* and I want to find out what is best. I guess it's that research mindset where I want to be involved in that practice knowing that, that's best for students and part of that sometimes is trying new things and taking the hat of *a researcher as a teacher*. I would also say I'm *quite reflective*, I *do blogs* and I always have a couple of entries going all the time, *reflecting on things that are happening* and I think that's something that helps as well, because you can sometimes see it forward what you are doing based on your reflection. [emphasis added]

Abbey's 10 years of teaching experience coupled with her curious personality and a desire to know helped to keep her focused on self-directed PD. In addition, being a reflective person also helped her to focus on this form of professional development.

Carol responded that she looked at the big picture and was not afraid to do what needs to be done. This attitude propelled her towards self-directed PD.

> I am a *big picture thinker*. I *know what I want and am not afraid to do* it. I think it is daunting for anybody to teach a new subject and without the desire to do better you just get stuck on the treadmill and you do it not knowing that *there is a better world and a better way to do it*. [emphasis added]

Carol's stance on wanting to do better and not being afraid to learn new things was her motivation towards self-directed PD. Ivan, with over 10 years in the teaching profession,

stated that his motivation to learn and ask questions and to be better at what he does in the classroom were factors that led him to self-directed PD.

> I think as a teacher, it's the *motivation to* want to learn. I think it's being *more willing* to be engaged in self-directed PD, which is also motivating. To be self-directed first is obviously more motivating. There is also this drive to have knowledge to be better, to go and look it up. So, I think what I try to do in my own teaching practice is to *instill that in students the need to learn*, the need to *ask questions*, the need to want to *search for things* or *where to look.* [emphasis added]

Ivan's desire to learn, to know, and to do better are character traits that he encouraged in his students. By doing this, he modelled for students a mindset that he saw as being necessary for learning and understanding mathematics. Carol and Ivan identified varying individual characteristics that were instrumental in their being involved in self-directed professional development. The other participants in their response to this question used phrases as: *lifelong learners, curious personality, driven, willingness to try new things, leader, perfectionists,* and *wanting to help students transition to another grade level*. The teacher-participants said these characteristics were important in helping them seek self-directed PD activities.

In the individual interviews, I also asked the teacher-participants to reflect on the experience they had had with self-directed professional development and to describe what they had learned about themselves as teachers. This question asked teacher-participants to reflect on their teaching experiences and their involvement in self-directed

PD. The intent was to determine if there are specific personal qualities that inclined them towards this form of professional development. Teacher-participants identified personal qualities and characteristics in themselves that appeared to motivate them towards self-directed professional development.

5.3.1 Summary of teacher-participant characteristics.

Teacher-participants identified several personal characteristics that they thought might help to explain why they were keen on self-directed professional development. Some of the commonalities in the responses of teacher-participants related to being (a) lifelong learners, (b) motivated to learn, (c) curious, (d) perfectionistic, (e) reflective, (f) willing to learn, and (g) big picture thinkers. All teacher-participants could describe a personal character trait that they felt attracted them to self-directed professional development activities.

5.4 Suggestions from Teacher-participants for Stakeholders (RQ3)

The third specific research question that framed this investigation was concerned with conditions that support teachers' engagement in self-directed PD. The question was: What are the conditions, if any, that support teachers' involvement in self-directed professional development? In the individual interviews I asked the teacher-participants to state what they would like stakeholders to know about self-directed PD. Stakeholders in this study refer to provincial boards, local school boards, administrators, MOE, and EFTO. The Elementary Teachers Federation of Ontario is the umbrella organization responsible for elementary teachers in Ontario.

The teacher-participants shared several suggestions on how self-directed professional development can be supported by policy makers. The suggestions included: (a) sharing best practices from beyond one's local school or board, (b) having more opportunities to collaborate with other teachers, (c) providing more PD in mathematics, (d) funding self-directed PD such as attending mathematics conferences, (e) accommodating differentiated mandated PD, and (f) allowing teachers to choose and customize professional development activities that are relevant to them.

Ivan's suggestions included teachers having more opportunities to look at best practices in the region and globally.

> I participate in Twitter chats around good and best practices right here in Ontario. Yes, I would [like stakeholders to know that *self-directed PD* is important]. I think that we need to *rethink the one size fits all approach* to teaching mathematics. The fact that we have to teach math in such a sequential isolated strand approach is very challenging for new and veteran teachers and who try open-ended problems. We have so many strands and we have to push through so quickly to make sure that we have done our best to cover all the expectations. So, I would like there to be *opportunities for us to explore and look at best practices,* not just within our own school board not just within our own province but perhaps *on a global perspective* to see what others are doing. [emphasis added]

Ivan asserted that mandated PD should offer opportunities for teachers to look at best practices in mathematics beyond the school board and the province. He stated that most of the best practices currently showcased in the mandated PD in his jurisdiction are from within the school or from within the school board.

Abbey, who had taught the Grade 2 for several years but who was now teaching another grade, indicated that she was interested in seeing opportunities for learning groups in mandated PD, especially from other schools.

> I would like to see *more learning groups*. I think that's really important and not just within your own school but having the opportunity to connect with others [from even other schools]. So right now, with this special math group am lucky enough to get to meet with other math teachers from our board. *I am investing a lot of time this year into my own PD and to the math itself* and am lucky that I have the time to do that. But I think offering more opportunities for teachers to connect would be very important. [emphasis added]

To Abbey it was important to make connections with other teachers, so she suggested that such opportunities should be made available to fellow teachers. Edna, who was involved in many different types of self-directed PD activities, argued that instead of giving PD days the MOE should fund self-directed PD in special programs and allow teachers to apply for funds to participate in projects in which they have an interest.

> You know we have PD days that are paid. Do not give me those days. Instead of giving me those two days, take all that money and put it in

> the pot, let people *apply for projects* but then you probably have people never doing professional development. I just wish that there were like… I do a lot of this with my own dollar: I *pay for my National Council of Teachers of Mathematics* membership *myself*. I pay to *go to conferences* and it's usually *on my time*. I wish that you could apply and have it *recognized, celebrated, and supported.* [emphasis added]

Edna suggested that more monetary support is needed to facilitate self-directed PD.

Barbara stated that self-directed PD should be facilitated as there are new ways of teaching mathematics but teachers are not aware of them.

> Facilitate self-directed PD. *I think we could all use training in math.* I feel like there has been some new research and there are *new strategies* and that there are many teachers who are not aware of these. [emphasis added]

Barbara's suggestion was that self-directed PD should be facilitated, as there are new ways of thinking about teaching mathematics and different approaches of which teachers need to be made aware. Harry proposed that professional activity day should be differentiated and coincide with conferences being held at universities.

> School boards (should be) encouraged to provide PD that is like *multiple modalities, maybe differentiated*. If a bunch of different educational stakeholders such as University of X or University of Y, different universities. If they were to hold, let's say *conference or*

> *workshops* on the day that we have PD days. Perhaps we *could get funding* for these but I think that you would find that that would be one of the areas where teachers would be a little more inclined to do something special. [emphasis added]

Harry wanted stakeholders to be aware that PD should be differentiated to meet individual needs and interests. He further suggested that there should be collaboration with school boards and universities so that conferences relevant to teachers would be held on the days assigned for professional activities.

Fay, in her response to the same question, mentioned that there are teachers who are uncomfortable with teaching mathematics. She felt that more time should be dedicated to self-directed PD. She was also of the opinion that stakeholders should give teachers more resources to use in their classrooms and allow them to pursue their own PD.

> There are a lot of people who are uncomfortable with teaching mathematics and I think there should be *more self-directed PD* and I would also like to see them (stakeholders) give you materials and hands-on material to use. Materials can be very expensive. They should provide PD but I think it's valuable for teachers to *pursue their own* (self-directed) PD. It would be good if there was more money provided for teachers to attend conferences where mathematics PD is offered. Quite often money is gone before a lot of people can take advantage of it. [emphasis added]

Fay believed that stakeholders should provide elementary teachers with opportunities to pursue PD that is of interest to them. She advocated for funding for teachers to attend conferences that offer PD in mathematics.

Similarly, Carol, the teacher with the shortest teaching career in this study—six years—supported the idea of stakeholders providing funding so that teachers could be engaged in whatever PD was of interest to them. She stated, "I would support the ministry providing funding for self-directed PD … whatever teachers want to do." It was important for Carol that teachers get funding for self-directed professional development activities.

In a similar manner, Donna suggested that stakeholders need to provide teachers with freedom and more time to collaborate with colleagues and discuss the planning of units and courses.

> So (stakeholders) give us more time, more freedom, *more opportunity to get together with your colleagues and discuss the unit planning*, the course planning and the making. Let it be five PD days, or workshops per year. Give us the freedom to choose. Instead of having me (in a PD session) just sitting here, thinking when is this going to be over. I could be in my classroom now. [emphasis added]

It was important for Donna that teachers had a choice in the PD in which they participated. Joe suggests that it would be beneficial if teachers could learn from what other teachers are doing.

> I think instead of having mandated PD, we (teachers) may benefit from *learning from other people and wanting to share what other people are learning*. Then we will spark others with our own self-directed PD. So for example, I may be great at Math but there are other areas in which I am not excelling. When people share their self-directed PD in that session, it would spark the interests of others. This is their passion. This [*sic*] what they are doing versus the *top down model* of thinking and I think a lot of our PD is top down. The MOE is saying it to the superintendents, who then say it to the principals who then say it to us and I don't think they (stakeholders) take in consideration a lot of other voices that are there, like current research or how to actually implement it in a classroom setting. [emphasis added]

Joe supported the idea that teachers should share what they are learning with their colleagues. The sharing among teachers, Joe opined, could serve as a catalyst to spark other teachers' interest in self-directed PD. He proposed that professional development as given by stakeholders should not follow the top down model.

Gary, while being cognizant that inquiry is built into the classroom experience, suggested that teachers need to be involved in their own inquiries as such inquiries can be built into the classroom experiences, which can lead to changes in the classroom.

> I don't know if we need to *change policies or we need to change structures*. Stakeholders need to foster creativity. There are policies on mandated (PD). And I know in certain schools they do whatever the

> MOE says but then go back to what they were doing (before). That isn't working. Stakeholders need to empower people to do changes. Inquiry is built into the classroom learning experience. Once we get teachers *engaging in their own inquiry*. Then once they find answers. They can enact things. They can *start doing things*. Maybe… foster a research base. [emphasis added]

Gary was of the view that teachers make changes through their own inquiry and that stakeholders should foster change by empowering teachers. The suggestions given by teacher-participants to stakeholders in education can be categorized thematically. These themes are: funding, collaboration, and facilitating self-directed PD. Teacher-participants in the study were aware that there are best practices that they could use to facilitate mathematics learning and teaching. They were also aware that some PD activities are costly and wanted funding to be available in the form of budgets for PD, so that teachers could participate in other learning activities. Collaborating with other teachers, schools, and boards and sharing partnerships with universities are other actions teacher-participants believed would facilitate self-directed PD. The teacher-participants agreed that there were other teachers in the province of Ontario or in other places who were using strategies that are working and argued that a connection with these teachers in a learning environment where ideas are shared would be beneficial. Having experienced the benefits of self-directed PD, teacher-participants would like stakeholders to facilitate self-directed PD so that they can improve their strategies for teaching mathematics.

5.5 Self-Directed Professional Development and Teacher Transformation (RQ4)

The fourth specific research question that framed this investigation was concerned with the degree to which self-directed professional development was transformational. The question was: What do teachers say is the impact of self-directed professional development on their teaching practice? I asked the teacher-participants the following questions in the individual interviews and the FGI respectively: After reflecting on your experiences in self-directed professional development in mathematics education, what have you learned about yourself as a teacher? (b) What have you learned about yourself as a teacher as a result of your engagement in self-directed professional development in elementary mathematics education? The teacher-participants' responses indicated varying levels of change, both personal and professional.

Fay, who had taught for more than 25 years, had much to say about the extent to which self-directed PD was transformational. She reported in the individual interview that in respect to her engagement in self-directed PD, her reliance on the textbooks had changed and that she was more aware of other approaches and different strategies for teaching mathematics.

> I think I was *reliant heavily* on the textbook or maybe a collection of textbooks to pull together lessons that followed specific sequence regardless of where my students were coming from and what their interests were. So now am more open to what their interests are and what are their abilities coming into math and I think also am more open

> to a variety of solutions. You know there are *different strategies to solving the same problems* and promoting that there are different ways to think about a new problem, and *not just one strategy works for everybody* and that even if we make mistakes we can learn strategies from each other and that you know math is not just about getting the right answer. [emphasis added]

Fay's response indicated that self-directed PD was partly responsible for the change in her practice and her thinking. She mentioned that before self-directed PD she had relied on the mathematics teaching package but she had since changed to using a variety of resources.

> I think before I was involved in self-directed PD I *would just rely on a teaching mathematics package*. Now I try to look *at a variety of resources* and I pick and choose what am going to use based on what my PD research investigation has told me are good for kids to do. So, I won't just pick up a teacher's manual or follow the manual. I will pick one lesson from there, or use another lesson that I may have found on the Internet. I might develop my own lesson, modify something, and work through progressively so that I have given the kids the experiences that they need and usually I get that idea of what the kids should be progressively working on what may be meaningful to them. [emphasis added]

I have shared this entire excerpt from a conversation with Fay because I find it noteworthy that she was a teacher with over 25 years of experience reporting on significant changes that occurred after her engagement in self-directed professional development activities. These change, she explained, included: (a) learning to use different strategies to teach, (b) searching for a variety of teaching resources, (c) recognizing that students need different approaches to learn, and (d) modifying lesson plans she searched from divergent resources, including the Internet. It is evident that Fay experienced what appears to be a profound change in her approach to teaching mathematics, as her teaching style was different after self-directed PD.

After reflecting on her practice, Abbey stated that before self-directed professional development her practice had been stagnating and she was not responsive to her students' needs.

> I think it [my teaching practice] was more stagnant before I became heavily involved [in self-directed PD]. I would say my teaching practices were *stagnan*t and less responsive. You know I would just kind of go through the motions and it wouldn't really be about whether the students understood or not … you opened up this section of the book and worked your way through it and that was that. It wasn't responsive to the needs of the students. *It was not differentiated* and I think definitely the second part of my career that I've definitely spent more time with self-directed PD. Now my teaching is more *dynamic and flexible* and my *plans are always changing*. It's *being flexible* and

> *responsive* to those types *of mathematical conversations* and that's important. [emphasis added]

Abbey had become more flexible in her teaching style. She had also changed the way she planned her lessons.

"Yes" was the response of Ivan when asked whether his practice had changed because of self-directed PD. The textbook was no longer the only resource material that he used for teaching mathematics. He now used the Internet for Twitter Chats and YouTube videos.

> Most definitely, absolutely, yes, 100%! I no longer *look to the textbook* to be the one and *only resource in my classroom*. I no longer look to the to the Internet to be one of the other (only) resources in my classroom with *YouTube videos* but am on *Twitter Chats* with my own school board and with another board discussing what they are doing in math. [emphasis added]

Ivan's response indicated that he had experienced significant changes in his approach to teaching mathematics because of his engagement with self-directed PD. He had used Twitter and YouTube as other resources for teaching mathematics. All 10 teacher-participants identified ways in which their practice had been impacted by self-directed professional development. However, two teacher-participants—Edna and Carol—explained that as soon as they began their teaching careers they had become involved in self-directed PD. Self-directed PD was not new for them. Nonetheless, their classroom practices were influenced by their engagement in self-directed PD. Carol stated that she has had several opportunities to be involved in self-directed PD.

> Because I was fortunate when I began teaching, we had ETFO money for self-directed [PD]. I don't know the difference of not having self-directed [*sic*]. You know what, I don't know life without it. I have always taken advantage of self-directed PD.

For Carol, self-directed professional development was part of her routine as soon as she entered the teaching profession.

Edna also expressed that she felt that as a professional she should always improve her craft. Self-directed PD was important to her as it provided her with ways to improve her teaching.

> You know my parent was a doctor and like every night he read journals. Like, that's just what he did. So, I just thought that as a teacher, you just *read professionally*. I just thought that was a part of it. So, I never had a time when I didn't want to *participate actively in improving my craft*. When you are a professional, you work on your craft. [emphasis added]

Edna's idea of what it meant to be a teacher included the need to read constantly and improve her craft as a mathematics teacher. For these two teacher-participants, engagement in self-directed professional development was the norm. They considered it a part of their professional role, an expectation of their roles as teachers.

Teacher-participants experienced transformation or change as they reported. This change occurred as a result of engaging in professional development that was self-

directed. The transformation teacher-participants described included using several different resources to enhance the teaching and learning of mathematics. The teacher-participants pointed out that their approaches to mathematics teaching had changed. They now accessed teaching ideas from online sources. Furthermore, they acknowledged that they *were no longer dependent* on one source for mathematics content and pedagogy; rather, they now used a variety of resources, from the traditional textbook to mathematics resources on the Internet. The processes of engaging in self-directed PD was transformational for teacher-participants. Their perspectives changed as well as their practice.

5.5.1 Self-directed professional development and change in practice.

I wanted to know if there were any significant changes to elementary teachers' practice because of self-directed professional development. To find out, I asked in the in-depth interviews if their practice had changed because of self-directed professional development. A corresponding question in the FGI was: What has been the difference in your approach to teaching elementary mathematics since you have been involved in self-directed PD?

Harry explained that in his involvement with self-directed PD he questioned everything and tried out different ways of teaching.

> I guess the difference in my approach is that I question everything, even if it is sort of a textbook or some sort of research paper presented to me.

> I question it *and I want to try it*. If it works great. *If it doesn't, I tweak it and try it again*. And that's the thing I want to do. [emphasis added]

Harry developed a questioning attitude because of self-directed PD and used it to make decisions on how and what to teach his students. Fay also asserted that her approach to teaching mathematics had changed, as it was no longer teacher-driven and she was using different instructional strategies.

> I think one of the things that I have gotten out of it is that I'm trying to get a *more deeper understanding of mathematics for my children*, in the sense that it is not teacher-driven, but it *is student-driven* and having the kids try to come to their own conclusions and not saying that this is the way that you have to do it. For the children to develop *their own learning strategies* that are meaningful to them and they can be successful with. I think I am now using a *lot of different types of materials and a lot of instructional strategie*s. You don't stay in your comfort zone and just pull out your lesson plan that you have been using every year for the last five years. It's always *looking for new and improved ways.* [emphasis added]

Fay shared that the change in her approach to teaching mathematics because of self-directed PD had transformed her classroom practice. Her approach was no longer driven by her ideas, but determined by the students' needs. She also incorporated a variety of materials and strategies in teaching mathematics.

Edna also commented that her approach to self-directed PD had changed over her career.

> I think that the way my approach to self-directed PD has changed over my career is that it has gone from bigger chunks like when I got my Master's degree and *focused on something specific in mathematics*. That *built on the foundational knowledge I acquired in the B.Ed. program*. Then, there are smaller questions, more specific things that I look for in mathematics teaching. [emphasis added]

Edna described how her pursuit of a Master's degree had helped to facilitate a change in her practice.

In the individual interview, I asked participants if self-directed professional development transformed their thinking about professional development in mathematics education. The specific question was: How has self-directed professional development transformed your perception and thinking about professional development in mathematics education?

Abbey noted that because of self-directed professional development she was now aware that there are many different approaches to teaching mathematics.

> I would just say that there is [*sic*] so *many different ways to approach* mathematical learning and understanding. Getting away from *just relying solely on the textbook and engaging students* in things that matter to them. That really comes through *self-directed PD and connecting with other people* and following others, *reading blogs to see other approaches* to teaching mathematics. Some of these approaches work for me while others do not work for me. [emphasis added]

Abbey acknowledged that she was now aware of many ways of approaching mathematics learning, which resulted in her relying on resources other than the textbook to engage her students in learning. She attributed this change to self-directed PD and her connection with other teachers through following blogs.

Barbara added that pursuing addition qualification courses was instrumental in helping her see other ways of teaching mathematics and had opened her eyes to different approaches in teaching elementary mathematics.

> I think I have finally gotten myself involved in more PD through my AQ courses. I think it *has opened my eyes* to a *different way of teaching math*, which we know our school board and our district have been promoting, but not in the schools that I've taught. I feel like I have more *strategies to teach* kids in a *variety of ways* and I feel the benefit will only be for the student and I feel they are able *to achieve success* best in math. [emphasis added]

Barbara asserted that self-directed PD had helped to change her teaching practice. She explained that this improvement in practice would benefit her students and lead them to success in mathematics. Donna also acknowledged that self-directed PD had helped her make changes in her teaching practice. She stated, "My understanding of a good PD opportunity is when *I transform my experience into action* [emphasis added]." For Donna, self-directed professional development resulted in change as she put what she had learned into action in her classroom.

For these teacher-participants, self-directed PD led to a change in practice. For example,

they were now aware of different ways of teaching mathematics. As a result, they no longer relied on textbooks as the sole source of information and instruction. Teacher-participants were putting into practice what they learned through self-directed PD. For the other teacher-participants in this study, self-directed PD appeared to change their practice in that it made them more comfortable teaching mathematics. They felt that students were engaged in more meaningful learning experiences as they were using multiple resources in their classrooms. The teacher-participants experienced the change in teacher practice in mathematics education in a variety of ways and they all acknowledged that their practice was impacted because of self-directed professional development.

5.5.2 Self-directed professional development and change in teacher perception.

In the individual interviews, I asked teacher-participants if their perception had changed after their engagement in self-directed PD. The question was: How has self-directed professional development transformed your perception and thinking about professional development in mathematics education? This question asked teacher-participants if their thinking had changed about professional development. Joe, who described his mathematics teaching experience as positive and had 10 years of teaching experience, reiterated that inquiry and learning were important features of his perception of self-directed PD. He said, “For me, PD has always been and should always be about trying to engage your fellow colleagues in talking, discussion and inquiry in learning.”

Joe's response focused on inquiry and engagement, while it underscored how his thinking had changed because of self-directed PD. Abbey also said that her thinking changed. She asserted that:

> Self-directed professional development has *changed my thinking* about mathematics as I find options, *or different ways of approaching mathematics* instruction to *fit the needs of students*. Being connected (to other mathematics teachers) and being willing to try new things and (improve) my own understanding of mathematics. [emphasis added]

Abby noted that she used different approaches to teaching mathematics to meet the needs of her students. In discussing his perceptions, Harry made connections between student learning and teacher learning.

> There are times when we (teachers) need to put ourselves in the position of the students to *really understand and feel that learning*. So, that when we come back to being a teacher again we have *a better understanding* of how we should go about teaching a concept. [emphasis added]

Harry stated that teachers need to place themselves in students' position so that they can understand how students learn and plan lessons accordingly.

For the teacher-participants, self-directed PD effected change in their perception as now they were: (a) using a variety of ways to teach mathematics, (b) focusing on teacher engagement and inquiry, (c) improving mathematical understanding, (d) teaching

mathematics in a way that is relevant to students, and (e) making assessments about students' understanding and using that information to make decisions about mathematics teaching. The data suggest that teacher-participants' perceptions changed about professional development in mathematics education because of their involvement self-directed professional development.

5.6 Chapter Summary

In sharing their understandings of self-directed professional development, teacher-participants described their perceptions of self-directed professional development, explained how they engaged in self-directed professional development, and shared the activities that provided them with self-directed professional development. They identified many and varied activities that they engaged in that are self-directed. The activities were classified into three main categories: Internet-based, individualized, and collaborative.

In addition to identifying activities that they engaged in, teacher-participants named personal characteristics as motivating factors for their engagement in self-directed professional development. Some of the characteristics named by teachers included their curiosity, motivation and willingness to learn and their reflective mindset. Self-directed professional development seemed to be very important to teacher-participants and they made suggestions on how stakeholders could support this form of professional development in Ontario. Teacher-participants understood self-directed professional development to be an alternative source for learning that supported their professional growth. The teacher-participants in this study understood that professional development

in elementary mathematics education was important and acted to facilitate their learning needs by engaging in self-directed professional development activities. Teacher-participants' actions indicate that they valued their professional learning and student learning.

Chapter 6

Discussion

6.0 Introduction

Self-directed professional development (PD) is professional development that is internally motivated and arises from the teachers own initiative (Eekelen et al., 2006; Mushayikwa & Lubben, 2009). In this study, self-directed professional development was understood as professional development that is teacher-driven and teacher-initiated. There is extensive research in education that supports the important role of professional development of the classroom teacher (Borko, 2004; Chapman, 2014; Darling-Hammond, 1995; Desimone, 2011). Wide-ranging research currently focuses on mandated teacher professional development but there is a dearth of literature on self-directed professional development in elementary mathematics education. It is against this background that I researched how elementary mathematics teachers perceive, engage in, and understand the role of self-directed professional development in elementary mathematics education.

In Chapter 5, I presented findings on the first four research questions of the study on the nature and role of self-directed professional development, the extent to which self-directed professional development is transformational, and factors and teacher characteristics, if any, which lead to self-directed professional development among elementary teachers. In Chapter 6, I specifically discuss the findings of the four research questions presented in Chapter 5. I also discuss findings of the fifth research question on the variation of teacher-participants' experiences with self-directed professional

development. I present the outcome space, which is a goal of phenomenographic research, delineating five categories of description on the phenomenon of teacher-participants engaging in self-directed professional development in elementary mathematics education. These categories of experiences are inductive themes that arise also from the findings of the first four research questions.

The self-directed type of professional development, as evinced by findings shared in Chapter 5, appears to cater to the individual needs of teachers and their students. In choosing individualized methods to foster professional development, teacher-participants addressed their individual learning preferences. The results suggest that elementary teachers are seeking professional growth in mathematics education through participation in self-directed professional development activities. Using the theoretical lens of Mezirow's transformative learning theory and Knowles' andragogy, I analyzed and interpreted teacher-participants' experiences with self-directed professional development. The analysis of and interpretation of the data indicate that teacher-participants faced a disorienting dilemma in their teaching and professional development. This dilemma led teacher-participants to seek their own learning activities and engage in activities that were relevant to their needs. Furthermore, teacher-participants were assertive in choosing professional development activities that improved their knowledge base, enhanced their proficiency, and fostered their personal and professional growth. Their inherent personal characteristics served as motivating factors. Teacher-participants experienced transformation as habits, practices, and changed perspectives.

6.1 Nature of Self-Directed Professional Development

What are the nature and role of self-directed professional development and how do teachers describe self-directed professional development in their mathematics teaching practice? To answer this question, I analyzed what the teacher-participants identified as the nature of self-directed professional development when they shared their understanding and contexts of self-directed professional development. Teacher-participants described the activities they engaged in and identified what motivated them to engage in self-directed professional development as well as the role it played in their professional growth.

Consistent in teacher-participants' description of the nature of self-directed professional development was the notion that self-directed professional development played a significant role that enabled them to foster personal and professional growth as teachers. Teacher-participants reported that self-directed professional development also helped expose their students to a variety of learning experiences. The teacher-participants valued self-directed professional development as an avenue for engaging in their own learning and professional growth, as well as in the learning of their students.

6.2 Variety of Experiences

In explaining the nature of self-directed PD, the teacher-participants described the various ways in which they engaged in this type of professional development. Their choice of self-directed professional development activities appeared to be directly related to their individual needs and preferences. The variety of ways in which teacher-

participants engaged in self-directed professional development included (a) using communication technologies such as Twitter, Internet searches, accessing websites, and following and writing blogs, (b) attending provincial conferences, (c) completing Additional Qualification (AQ) courses, (d) pursuing graduate studies, and (e) reading mathematics resource books. The self-directed professional development activities identified by the teacher-participants can be further classified into three categories: internet based, individualized avenues and collaborative. Lieberman and Mace (2010) agreed that with the advent of the computer technologies, teachers now have access to a variety of online resources that can help with lesson preparation and delivery. This research has similar findings regarding the use of the Internet as a source of professional development.

In addition to using online resources, teacher-participants reported that they engaged in self-directed professional development through action research with colleagues through a provincial teachers' organization, the Elementary Teachers Federation of Ontario (ETFO). Teacher-participants also participated in Teacher Learning and Leadership Projects (TLLP) funded by the Ontario Ministry of Education (MOE). Teachers collaborate with others when they work on ETFO and TLLP projects, where they form collegial relationships and learn new strategies for teaching. Collaborating with and learning from other teachers, whether on projects within or outside of their schools through self-directed professional development, appeared to enable teacher-participants to foster a more helpful understanding of mathematics teaching practices and of how students learn mathematics.

Reading books written by mathematics educators, reading research papers and other professional material, creating a teaching guide in elementary mathematics with peers, and researching mathematics and technology online are other ways in which teacher-participants engaged in self-directed professional development. The teacher-participants seemed to be proactive and were making deliberate attempts to facilitate their own learning and teaching. In addition, they were changing and shaping classroom practice by providing engaging and meaningful mathematics lessons.

While teacher-participants described a variety of ways in which they engaged in self-directed professional development, I noted that their use of social media platforms was prevalent. The use of social media, surprisingly, did not vary by years of teacher-participants' teaching experience. It appears that the easy access that all teacher-participants had to this avenue made it a convenient resource for professional development. Through the ubiquitous Internet and social network platforms teacher-participants, were finding ways to advance their professional practice as they enhanced their knowledge, skills, and attitudes related to teaching. Through this research, I conclude that teachers highly value Twitter as a means of self-directed professional development. This finding corroborates Visser et al. (2014) study that concluded that Twitter plays an important role in informal professional development of teachers. Using Twitter proved to be a transformative experience for professional growth that generated meaningful changes in teachers' instructional practice (Noble, McQuillan, & Littenberg-Tobias, 2016).

Writing blogs, another feature of social networking and of the Internet, was an important means by which teacher-participants engaged in self-directed professional development. Visser, Coenders, Pieters, and Terlouw (2013) claimed that it is important to understand that teachers choose to pursue this informal method of professional development as opposed to the conventional means because it affords them the autonomy to select their own professional development. There is documentation to support teachers' use of the Internet for professional development in mathematics education (Duncan-Howell, 2010; Patahuddin, 2008; Saville, 2013).

The use of social media afforded teacher-participants the option to continue their professional development and to use their time before or after work to facilitate professional growth. Gellert (2008) argued that teachers often report that they work in isolation. However, when elementary teachers engage in self-directed professional development that involves the use of the Internet, blogging, and Twitter they are no longer in isolation but are collaborating with other possibly like-minded professionals and are becoming members of virtual learning communities. It is evident that elementary teachers are pursuing professional development in a variety of ways that suit their individual needs. It is clear from the study that while teacher-participants found a variety of ways to engage in self-directed professional development, access to technology as a professional development learning avenue was greatly valued. Teacher-participants seemed to have embraced a culture of learning where they sought ways to fulfill the needs they had identified. Collaboration, whether through working on projects face-to-face or online through blogging, provided teacher-participants with an avenue to further their professional growth. Seeking their own professional development was

emancipatory for teacher-participants. This emancipation led teacher-participants to make choices about their learning and act on the learning they received. Phase 5 of Mezirow's *Ten Phases of Transformative Learning* identified exploration of options, relationships, and actions as an important step in the transformational process. This deliberate effort by teacher-participants to develop themselves in areas of need and area of interest demonstrates that teacher-participants were committed to their professional development. Teachers' efforts to foster their professional growth can lead to improvements in teachers' knowledge, instruction, and student outcomes (Hill, 2009; Mushayikwa, 2011, 2013).

Teacher-participants engaged in self-directed professional development in mathematics in multiple ways. When teachers' knowledge is improved because of professional development, it may lead to increased achievement in students (Hill, Rowan, & Ball, 2005; D.H. Jarvis, 2006). While explaining the nature of self-directed professional development, teacher-participants concluded that its role in their practice was major, as they reported that teacher change in practice, teacher learning, and student learning were related to their involvement in self-directed professional development. Self-directed professional development took many formats but the results were the same: teacher-participants were equipped with new content knowledge and new pedagogical practices for teaching and learning mathematics.

Participants reported that being involved in self-directed professional development helped them learn different techniques for teaching mathematics. One teacher-participant in this study acknowledged that one of the benefits of self-directed

professional development was that it allowed for customized professional development, which was not only convenient and relevant but also related to a specific learning need that the teacher wanted to fulfil. The teacher-participants shared that the learning they received from reading research in mathematics education and other resource materials was instrumental in transforming their classroom practice. Day (1999) observed that professional development provides the teacher with knowledge and skills and the acquired knowledge and skills are beneficial when transferred to the classroom.

6.3 Self-Directed Professional Development and Teacher Transformation

The second research question asked teacher-participants to what extent self-directed professional development was transformational. The teacher-participants reflected on their practices and shared how their perception and classroom practice changed. All teacher-participants explained that there had been a notable change in their practice. These changes related to how they perceived mathematics and how they approached the teaching of mathematics. Teacher-participants' view of self-directed professional development is that it produced both change and improvements in their daily classroom practices.

The first major change from the findings related to the teacher-participants' perception, which led to perspective transformation. Mezirow's (1991) theory refers to this adjustment as change that result in behavioral and convictional change. Teacher-participants were now more confident with teaching mathematics. This change in perception resulted in teacher-participants choosing to use varied instructional

mathematics resources that helped them adjust their teaching methodologies to complement students' learning styles and to offer different learning experiences for students. The teacher-participants were also developing a questioning approach to mathematics teaching while seeking a deeper understanding of mathematics.

Two teacher-participants shared that since they had started their teaching careers they had pursued self-directed professional development activities. For these two teacher-participants, engagement with self-directed professional development was embedded in who they were as professionals. It felt normal for them to be engaged in activities described as self-directed. Edna was one of these teacher-participants. In responding to this question said that she thought it was a natural part of being a teacher to review articles and resources published for professionals and to read professionally. She said, "I never had a time when I didn't want to participate actively in improving my craft."

Likewise, Carol explained that when she began her teaching career she was fortunate to receive funding from ETFO for engaging in self-directed professional development. She said, "I don't know the difference of not doing self-directed professional development. I have always taken advantage of (opportunities for) self-directed PD." Just as it was for Edna, it was natural for her to participate in self-directed professional development activities. When the other eight teacher-participants described their engagement with self-directed professional development, they also narrated how they experienced change in their practice. They related that this change allowed them to teach mathematics in different ways. This change in practice as noted by Mezirow (1994)

appeared empowering for teacher-participants as they made choices about their own learning and that of their students. Their habits changed. Habits and actions related to their use of textbooks and the inclusion of other mathematics teaching resources, for example, changed.

Mezirow's transformative learning theory, as described in Chapter 3, identified changes in perspective. When perspectives change, habits change. In the case of the teacher-participants, their habits changed in terms of which resources they used and how they used them. The perspective changes made by teacher-participants were reflective of instrumental learning as they made decisions to control their environment (Mezirow, 1996). Teacher-participants controlled their situation by seeking professional learning when it was needed. The andragogical model proposed by Knowles (1984) assumed that adults are ready to learn when they need information. Teacher-participants in this study demonstrated that competence by seeking and learning material that they needed for their practice.

The second major transformation that teacher-participants acknowledged was moving away from relying solely on mathematics textbooks to using multiple resource materials. Exposure to other resources then occasioned teacher-participants to adapt different approaches to teaching mathematics. One teacher-participant asserted, "I began teaching mathematics in a more engaging manner and teaching the mathematics that mattered to students." The teacher-participants explained this change in approach as resulting from connections and collegial relationships that the teacher-participants formed while engaged in self-directed professional development activities.

Mezirow (1994) argued that perceptions are influenced by habits that in turn constitute one's frame of reference. Teacher-participants' habits changed when they moved away from solely relying on the mathematics textbook as a resource. Teacher-participants' assumptions about the importance of the mathematics textbooks were influenced by the multiplicity of resources to which they were exposed while engaged in self-directed professional development. After reflecting on how self-directed professional development was affecting their teaching, their assumptions changed. This change in teacher-participants' habits and perceptions led to a third change in relation to teacher-participants' thinking about mathematics.

The third transformation that teacher-participants experienced was the change in their thinking about mathematics teaching. The change in teacher-participants' thinking is the result of their critical reflection. This is also Phase 3 of Ten Phases of Transformative Learning, which involves a critical assessment of epistemic, sociocultural, or psychic assumptions. Knowles (1975) enjoined that adults make decisions after critical reflection that in turn can lead them to make changes and facilitate more learning. From their connections and collegial relationships with teachers who were using different approaches to teaching mathematics, teacher-participants gained new insights on mathematics teaching. The teacher-participants described having more options in the way they approach teaching mathematics to fit the needs of their students. The teacher-participants stated that through self-directed professional development activities they were introduced to different ways of teaching mathematics. It was interesting to note that the transformation reported by teacher-participants did not reflect any gender biases. Further, the teacher-participants' years of service in the teaching

profession, whether novice or expert, did not affect the transformation reported by the teacher-participants.

In describing the change that they had undergone, the teacher-participants reported that they had searched the Internet for mathematics resources and created differentiated learning experiences for students. Teacher-participants' actions in seeking mathematics resources resulted in teacher-participants having a deeper understanding of mathematics in addition to responding to students' mathematical conversations. The teacher-participants used technologies to facilitate their professional development by adding YouTube videos, Twitter, and other Internet resources to their repertoire of teaching and learning activities. It is evident, based on their reports, that the teacher-participants are using new Internet-based technologies to effect change in their learning and practice. This change has implications for practice because teacher-participants are responding to their own learning needs and to the learning needs of their students.

The fourth way in which the teacher-participants said they were transformed related to educational achievement. They mentioned their engagement in advanced education as a form of self-directed professional development. This transformation was evident in the formal self-directed professional development activities that they pursued such as master's degrees and AQ courses certified by the MOE and offered at faculties of education at universities in Ontario or by ETFO. The teacher-participants' pursuit of educational opportunities is self-directed, as it is not a mandated requirement for teachers in Ontario.

Teacher-participants' decision to pursue these courses reflected an understanding of the importance of professional development in education as well as an understanding of the need for mathematics learning to be more relevant and enjoyable to students. It is interesting to note that teacher-participants did not mention the cost of these AQ courses as a deterring factor. In a study conducted by Williams (2016), he concluded that teachers were mindful that the cost of AQ courses was a barrier to their professional development, as they considered these courses expensive. While there is research suggesting that the prohibitive cost of AQ courses is a challenge, for the teacher-participants in this study it was not a factor in pursuing graduate degrees and AQ courses.

The transformation reported by the teacher-participants resulted in changes in their thinking, changes in their practice, changes in the resources used to teach mathematics, and changes in their approach to mathematics education. The changes made by the teacher-participants provided agency as they were positioned to be more confident in their knowledge and ability to provide mathematics-learning opportunities for their students. In Chapter 3 I identified Mezirow's principles that guide transformative learning. The third principle stated that change to meaning structures occurs through reflection about content, process, or premises (Mezirow, 2000). This is also Phases 7 and 8 of the Ten Phases of Transformative Learning, which is about acquiring knowledge and skills for implementing one's plans and provisionally trying new roles, respectively. Teacher-participants reported that their engagement with self-directed professional development resulted in transformational changes in relation to their classroom practice, which further influenced how they taught mathematics, how they chose teaching materials, and the activities they participated in to promote their own

mathematics learning and that of their students. The transformative learning theory that framed this study aligns with Knowles' (1975a) view that adult learners have choices. Based on their perspectives, adults choose the learning material that fits their needs and interests. Teacher-participants chose learning activities that were relevant and used the learning to change their habits and assumptions.

Self-directed professional development provided teacher-participants with opportunities to acquire and share knowledge and skills needed to enhance mathematics learning in elementary schools. From the data collected, it is evident that self-directed professional development is transformational for teachers, as it is affecting their pedagogical practices and thinking in mathematics education. The changing of pedagogical practices to ensure student learning augurs well for mathematics education as teachers are promoting and applying pedagogical practices that are relevant and engaging for elementary students.

As I cited in Chapter 2, there is extensive research on teacher practice and teacher change (Clarke & Hollingsworth, 2002; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 2001; Guskey, 1986; 2002; 2003; Lampert & Ball, 1998; Raymond, 1997). In this research, the changes that teacher-participants experienced enabled them to engage in new ways of teaching and learning mathematics. What teacher-participants mentioned as transforming in their practice appeared to result in changes to their approach to teaching and to their thinking in elementary mathematics education. Teacher professional development can affect classroom practice and can promote change in an era of educational reform (Borko, 2004; Porter et al., 2004). Further, teacher professional

development has been linked to improvements in teachers' knowledge, instruction, and student outcomes (Hill, 2009).

As teacher-participants talked about their work and self-directed professional development, they shared stories explaining how their classroom activities have been enriched because of self-directed professional development. Self-directed professional development, for the teacher-participants, resulted in significant changes in their professional practice.

6.4 Teacher Characteristics

What are the factors and teacher characteristics, if any, that lead to self-directed professional development among elementary teachers? Since teachers are the main resource in the education system, with Research Question 4, I sought to understand what teacher-participants thought about themselves in terms of the personal qualities that may incline them to engage or not engage in self-directed professional development. When the teacher-participants were describing themselves, they included such terms as (a) perfectionists, curious, with a research mindset; (b) reflective; and (c) big picture thinker. The characteristics that teacher-participants identified may have stimulated them to engage in reflection, according to Mezirow (2000), which caused them to decide to make changes and be engaged in self-directed professional development. Table 6.1 highlights the personal characteristics identified by teacher-participants that related to their participation in self-directed professional development activities.

Table 6. 1 Personal Characteristics Identified by Teacher-participants

Teacher-participant Characteristics
I am a:
Lifelong learner—I am not satisfied to keep my practice the same way
Driven person—I am a perfectionist
Curious person—I am willing to take risks
Learner
Leader
Big picture thinker
Reflective practitioner
Self-reflective person
Risk taker
Questioner
Knowledge seeker

According to Minott (2010), it is important for teachers to reflect on their practice, their style, and the way they engage in the teaching and learning process. Not only were the characteristics identified by teacher-participants positive, but the teacher-participants expressed the view that they would like their students to develop some of these character traits as well. It is interesting to note that when talking about their personal characteristics, the teacher-participants did not refer to their beliefs, attitudes, identity, self-efficacy, and conceptions. These constructs are commonly identified in research on teacher characteristics.

6.5 Variation of Teacher-participants' Experiences with Self-Directed Professional Development (RQ5)

Research Question 5 (RQ5) was concerned with the variations of experience reported by teacher-participants who engaged in self-directed professional development. Teacher-participants' descriptions and explanations of their engagement with self-

directed professional development seem to indicate that teacher-participants experienced it in a variety of ways. To understand the variation of teacher-participants' experiences with self-directed professional development, it was necessary to look carefully at how teacher-participants' descriptions were either different or similar. Different categories of description emerged from the data. Each category had to be substantiated to ensure trustworthiness.

6.6 Categories of Description

Phenomenographic research looks at the qualitatively different ways in which people experience a phenomenon. I introduced this construct of variation of experience in phenomenographic research in Chapter 4. The focus of phenomenographic research is on the variation in the experiences of a group of people (Trigwell, 2006). One of the purposes of this study was to understand the qualitatively different ways in which elementary mathematics teachers experience self-directed professional development.

Categories of descriptions, unlike the findings presented in Chapter 5, are higher-level inductive themes that arise from iterative data analysis process. The process of identifying these categories goes beyond transcribing, reading, member checking, and coding, inter-coding, and thematic analysis. It is like what is referred to in grounded theory, in which patterns and variations are accounted for by systematic coding. In phenomenography, the categories of description that emerged from the data analysis are to be logically related and hierarchically organized. The categories of description that emerge are said to form an outcome space.

Foster (2013) stated that the strength of phenomenography is its "ability to develop logical structures that give a picture of the experience while being able to read into the structure the complexity as is consciously and practically possible" (p. 30). In this study, the individual interviews and the focus group interview generated an outcome space that comprised five levels of conceptions teacher-participants had about their engagement with self-directed professional development in elementary mathematics education. Here are the categories of description on teacher-participants' experiences with self-directed professional development:

Category A: Variety of experiences

Category B: Individualized professional development

Category C: Benefits to students and teachers

Category D: Learning with and from others

Category E: Transformation in practice

In generating the outcome space, it should be noted that, as is the case with phenomenographic studies, one individual's conceptions were not the basis for arriving at conclusions. Rather, it was the cumulative expressions from the individual interviews and the FGI that yielded the outcome space of five categories. All five categories of description are hierarchically related. The results of this study indicate that Category A, comprising a variety of experiences, served as a springboard for the succeeding categories. There seems to be a relationship between Categories A and B. As teacher-participants sought a variety of ways in which to learn in mathematics education, they

were involved in individualized professional learning. Category B, individualized professional development, seems to be a direct result of teacher-participants having to choose from a variety of experiences in self-directed professional development. Category B aligns well with Category C, which looks at how students and teachers benefit from the individualized ways in which teacher-participants engaged in professional learning. Category D, learning with and from others, addresses the collaborative impact of self-directed professional development and seems to be directly related to Categories A, B, and C. Based on teacher-participants' responses, their collaboration with others resulted in knowledge that they later transferred to their mathematics classes. Category E, transformation in practice, seems to be a direct consequence of all the preceding categories. Figure 6.1 shows how the five categories are related to each other. All teacher-participants because of all their experiences with self-directed professional development reported transformation in practice. A close examination of the data revealed that while the experiences of teacher-participants were varied, there was one common element: the teacher-participants experiences the desire to be better at teaching elementary mathematics. The teacher-participants' experiences in self-directed professional development led to both personal and professional transformation.

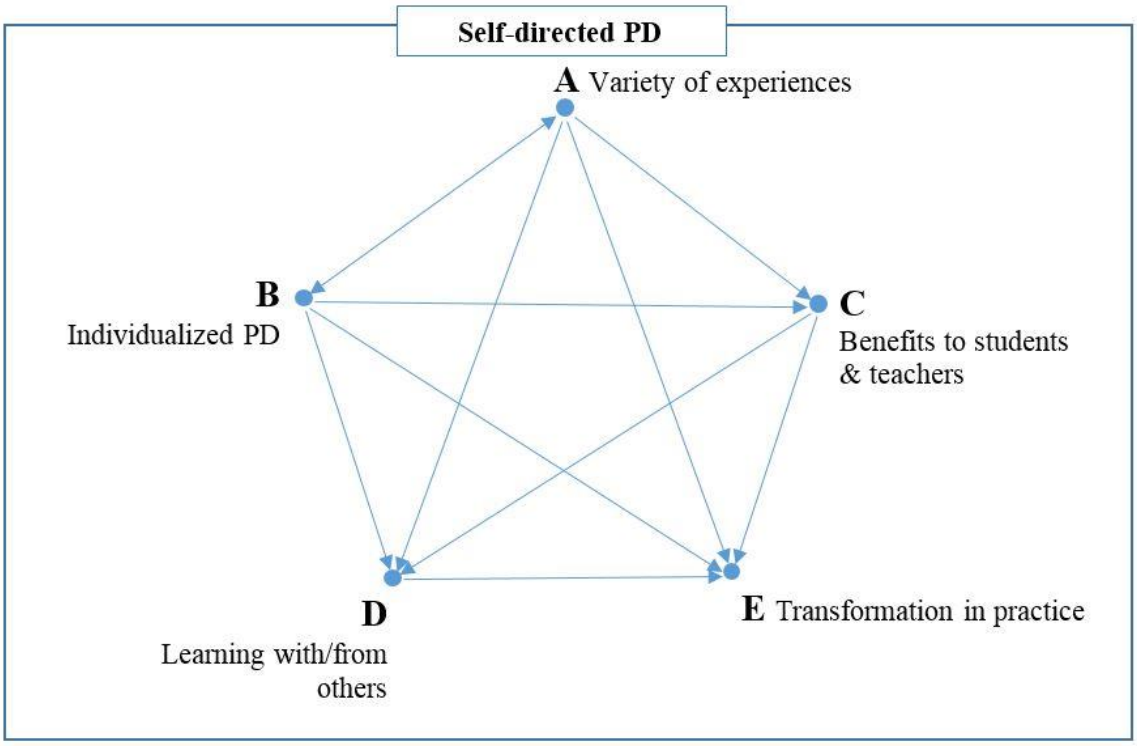

Figure 6. 1 Relationships among categories of description

6.6.1 Category A: Variety of experiences.

Category A of *variety of experiences* emerged from teacher-participants' illustrations of the many different activities in which they had taken part in while engaged in self-directed professional development. In responding to the question about the nature and role of self-directed professional development and how they described self-directed professional development, teachers reported a variety of ways in which it influenced their practice. Teachers reported on the variety of experiences that they were engaged in while participating in self-directed professional development. These activities included the use of Twitter, following and writing blogs, going to conferences, reading current professional development resources, pursuing AQ courses and master's degrees, and reading research papers.

In section 5.2.4, I revealed a variety of ways in which teacher-participants engaged in self-directed professional development activities. Their learning improved as they became aware of the teaching and professional development practices of the other elementary teachers in mathematics education. Connecting to other educators was a way to keep abreast of new ways of thinking and doing mathematics. It provided a means by which teacher-participants engaged with professional learning communities (PLCs). As I discussed in Chapter 2, PLCs are beneficial because they provide opportunities for teachers to collaborate with their colleagues and learn different ways of presenting mathematical concepts to students.

6.6.2 Category B: Individualized professional development.

Category B, *individualized professional development*, emerged from teacher-participants' acknowledgment that self-directed professional development afforded them the opportunity to be engaged in professional development activities that were convenient and relevant. The customized and individualized professional development activities that teacher-participants engaged in were appropriate for their needs and schedules.

Teacher-participants participated in self-directed professional development activities that: (a) fulfilled teachers' needs, (b) answered questions they had about certain topics, and (c) clarified misconceptions they may have had on topics in their immediate classrooms. Teacher-participants reported that this the ability to choose the type of professional development that they needed individually was important as it filled a specific role that was pertinent to their practice.

Sikes (2011) contended that professional development programs within schools should provide differentiated learning opportunities for teachers and provide a focus for student learning. To avoid the mismatch of professional development that does not address specific needs, teachers need opportunities for targeted content-based professional development that is differentiated to their level and their needs (MacFarlane, 2012). In this study, teacher-participants agreed that self-directed professional development filled that gap by allowing them to engage in professional development activities that were personalized according to their individual needs.

6.6.3 Category C: Benefits to students and teachers.

In Category C, *benefits to students and teacher*, the teacher-participants reported that self-directed professional development was beneficial to their students and to themselves. I grouped benefits to students and benefits to teachers together because of the reciprocal relationship between the two. The range of benefits that the teacher-participants experienced included being more knowledgeable, using lots of manipulatives, and wanting to be better at teaching. While teacher-participants were actively pursuing self-directed professional development activities and increasing their learning they were providing a variety of learning experiences for their students. Mezirow (1994) maintained that transformational learning has value as it allows individuals to improve their instrumental and communicative competence. Instrumental learning influenced teacher-participants to take charge of their learning needs by engaging in learning activities that fulfills specific needs. Mezirow (1991) stated that transformative learners move towards a frame of reference that integrates experience.

The integration of experience was evident in the reported actions of the teacher-participants as they used the professional learning opportunities they engaged in to change the classroom experience of their students.

This benefit was evident when teacher-participants described how their students were more willing to take risks and were developing a sense of inquiry in their approach to mathematics learning. Teacher-participants also benefitted by learning new content and having different choices in terms of teaching strategies used in their classroom. From teacher-participants' descriptions, the benefits were almost like a symbiotic relationship in which their engagement with self-directed professional development directly changed their classroom practice. It was beneficial because it provided the teacher-participants with opportunities to learn new ways of teaching and it was beneficial to students, as they introduced new ways of learning mathematics.

6.6.4 Category D: Learning with and from others.

Category D, *learning with and from others*, emerged as teacher-participants highlighted how they engaged with other teachers whether at conferences, via Twitter, on blogs, or through action research. The statements made by teacher-participants suggested that these connections with other educators were important for their learning of helpful teaching skills and strategies. Knowles' (1984) andragogical theory about adult learning identified that self-directed adults can work with and without others. Teacher-participants in this study demonstrated that they could work with others when they collaborated on projects, shared insights on how to teach, and followed blogs that provided interesting ways of engaging students in learning.

Connecting to other educators through social media, attending conferences, conducting action research and writing projects are ways in which teachers keep abreast of new ways of thinking and doing mathematics. The flexibility to interact with other teachers via social media for self-directed professional development was convenient. Teacher-participants accessed these resources on their own time, at their own convenience, and in their own space. Teacher-participants' interactions resulted in learning that proved beneficial to the teachers themselves and their students. In reviewing 80 studies on teacher collaboration, Vangrieken, Dochy, Raes, and Kyndt (2015) concluded that when teachers collaborate, it impacts students' engagement and school cultures. As evidenced in the teacher-participant quotes presented in Chapter 5, teachers collaborate when they work on projects at the school level or even at the provincial level. The collaboration that results from teachers learning from and with others provides teachers with not only a sense of community but with knowledge, skills, and attitudes that enhance their teaching and, potentially, the learning in their classrooms.

6.6.5 Category E: Transformation in practice.

The final category, Category E, *transformation in practice*, is the result of self-directed professional development in both thinking and practice. One of the key assumptions of Mezirow's theory of transformative learning is that for transformative learning to occur the learner must make an informed decision to act. This informed act is done after critical reflection on an individual`s circumstances. Engagement in self-directed professional development was evident in the teacher-participants' action on their

desire to be more competent, to learn more mathematics, and to offer a variety of learning experiences to their students.

Further, Category E encapsulates the degree to which self-directed professional development contributed to bringing about change in teacher-participants' approach to teaching elementary mathematics and in their perspectives about mathematics teaching and learning. The teacher-participants reported that this transformation of practice and perception was also evident in their students' thinking. The first four categories of description appeared to be the source of the transformation that teacher-participants experienced.

The transformations that teacher-participants described indicate that self-directed professional development is a powerful way of providing agency for elementary mathematics teachers. It promotes change. This change or transformation occurs in teachers' practice and thinking, and it affects the teaching and learning process in the classroom. When teacher-participants noted that their practice was transformed because of self-directed professional development, this means that self-directed professional development has a role to play in teacher professional development. It also means that this form of professional development is filling a niche that is not currently being met by other forms of professional development.

Teacher change, like most change that happens in professional practice, must emanate from within. In this study, teacher change was evident, as reported by teacher-participants. The basis for the change in practice, which resulted in transformation in elementary mathematics classrooms, was a personal desire for professional development

that was specific to the learning needs of teachers. One of the keys to improving education is the classroom teacher. Students must have skillful, highly effective teachers who have consistent access to on-going professional development (Stahl, 2012). Self-directed professional development, based on the reports of teacher-participants, can provide teachers with teaching strategies that can equip them to foster change in teaching and learning.

The five categories of description, namely variety of experiences, individualized professional development, benefits to students and teachers, learning with and from others, and transformation in teacher practice, indicate that there is a place for self-directed professional development in elementary mathematics. Given the high stakes in education today, self-directed teacher professional development is integral in maintaining the teacher factor. This professional development method can play a supplementary and complementary role to mandated professional development. In other models, trainers are responsible for ensuring that teachers learn, whereas in the self-directed model the teachers as learners explore their will to learn, monitor their knowledge, and regulate the process. The outcome space in the present study represents the range of ways in which elementary teacher-participants experience self-directed professional development in mathematics teaching and cannot be attributed to any other phenomenon.

Through the lens of Mezirow's transformative learning theory and Knowles' andragogy, self-directed professional development as experienced by the teacher-participants provided a nuanced look at professional development. Transformative learning occurred as teachers (a) assessed their learning and that of their students, (b)

searched for learning options, (c) planned how they would acquire mathematical knowledge, (d) acquired knowledge to improve their classroom practice, and (e) confidently used the approaches that they learned, and the knowledge gained to facilitate and foster change in their classrooms.

6.7 Chapter Summary

The experiences of teacher-participants in this study provided a view of how teacher-participants negotiated and facilitated their professional growth in elementary mathematics education through self-directed professional development. In this chapter, I identified the various ways in which self-directed professional development was instrumental in the transformation of elementary mathematics teachers. Teacher-participants were transformed in their thinking and practice and how they approached the learning and teaching of mathematics. I identified an outcome space of five categories of description that were hierarchically related to each other. Teacher-participants used a variety of ways to foster their learning in mathematics education, which became the catalyst for transformation. This that would seem to suggest that teacher-participants were maintaining their professional identity by controlling their learning needs and goals through self-directed professional development.

Chapter 7

Conclusion

7.0 Research Overview

In this qualitative study, I focused on self-directed professional development in elementary mathematics education. The main purpose of the study was to understand elementary teachers' conceptions of self-directed professional development in mathematics education. The underlying question on which I based this study is: How do elementary teachers perceive, engage in and understand the role of self-directed professional development? The specific questions that framed this research are:

1. What is the nature of self-directed professional development activities in which teachers are engaged and how do teachers experience self-directed professional development in their practice?

2. What are the factors and teacher characteristics, if any, that lead to self-directed professional development among elementary mathematics teachers?

3. What are the conditions, if any that support teachers' involvement in self-directed professional development?

4. To what extent is self-directed professional development transformational?

5. What are the variations of experience reported by teachers who engage in self-directed professional development?

The methodological framework I used was phenomenography. Phenomenography examines the qualitatively different ways in which people experience, interpret, understand, perceive, or conceptualize aspects of their reality (Marton, 1981). Mezirow's transformative learning theory and Knowles' andragogy provided the theoretical lens through which I analyzed and interpreted teacher-participants' experiences with self-directed professional development.

7.1 Limitations of the Study

The findings and interpretation of the data discussed in this research are applicable only to the teacher-participants who identified themselves as being engaged in self-directed professional development. The findings of this study cannot be generalized. The aim of qualitative research is not to generalize, but to transfer the findings, where applicable, to populations with similar characteristics. Therefore, the findings of this investigation cannot be generalized to elementary teacher populations in Ontario. In addition, this study took place in a context and did not consider different school cultures and other considerations that may influence other teachers' experiences.

Another limitation of this study is that I did not observe teacher-participants in their classrooms. Thus, the extent to which teacher-participants transformed their classroom practice is based on their remarks rather than from observing directly their change in perceptions and understanding while teaching or when engaging in self-directed professional development activities. To use observation as an instrument of data collection would further triangulate the data, as well as offer a window into gaps, if any, that may exist between what teacher-participants reported and their actions.

As I mentioned in Chapter 5, a few questions were unique to both the Focus Group Interview (FGI) and the individual interviews. If I were to do this study again, I would revise the data collection instruments in a number of ways. I would closely match the interview and focus group questions so that the focus group corroborated with the individual interviews and vice versa. I would also expand the interview and focus group questions on supports teachers would like stakeholders to know about self-directed professional development. I would also include questions on support from colleagues, the community, and the teaching environment. I would delay sharing my understanding of self-directed professional development, until after hearing from all the teacher-participants about their understandings based on their professional practice and immediate experiences.

7.2 Significance of the Study

This study has shown how teacher-participants perceived, engaged in and understood self-directed professional development. It continues the discourse on the complexities surrounding teacher professional development and how teachers in the field perceive its importance. The value of this research lies in the contribution it makes to the body of knowledge on self-directed professional development, particularly as it relates to how elementary teachers perceive, engage in, and understand self-directed professional development. It adds to the discourse on professional development in general and specifically to professional development in mathematics education. This study also contributes to the body of phenomenographic research in curriculum studies. The literature on self-directed professional development in elementary mathematics education

is limited and this study provides another view through phenomenography on how teachers view their engagement in and benefit from professional development. In addition, this study fits into the larger discourse on teacher professional development and provides insights on activities that can foster teachers' growth and development.

This research corroborates the view that self-directed professional development can evoke change teachers' thinking about mathematics teaching and teaching (Chapman, 2013). The transformation reported in the findings is in line with Mezirow's (2000) learning theory that explores the transformative perspectives of adults. Knowles' (1975a) view that adults choose the learning they need and apply them was also evident in this study. This is aptly demonstrated by the teacher-participants who, prompted by their learning needs and interests and those of their students, made decisions about their learning needs in mathematics teaching and learning. Using Mezirow's theory of transformative learning as the lens through which to understand how elementary teachers perceive, engage in, and understand self-directed professional development allowed me to understand the processes involved as teacher-participants' actions depicted some of the phases identified by Mezirow. Some of the phases identified include (a) a disorienting dilemma, (b) recognition of one's discontent, (c) exploration of new role, relationships and actions (d) acquisition of knowledge and (e) building of competence and self-confidence. Minot (2010) identified one of the benefits of self-directed professional development as the ability to address individual needs. In addition to addressing teachers' needs, it resulted in an emancipatory experience as teachers controlled their professional learning in terms of time, content, and context. Although not explicitly

stated in all cases, the element of reflection played a role in teacher-participants' decision to be engaged in self-directed professional development.

The study reflects the extent to which these elementary mathematics teachers value their professional development and foster it through multiple means. Teachers demonstrated their capacity to bring about change in their professional learning and the mathematics learning experiences of their students. This change resulted from teacher-participants' ability to access learning opportunities that filled their own immediate needs and the needs of their students. The five categories of description and the different avenues for self-directed professional development show that self-directed professional development is multifaceted. It changes practices and impacts teachers. Self-directed professional development provided the teacher-participants with autonomy in that they decided what they needed to learn and chose activities consistent with their needs.

Cranton (1996) suggested that traditional forms of professional development do not give teachers that sense of responsibility, as teachers are mostly involved in professional development activities that are provided by authorities based on their assumptions of teacher's needs. However, by engaging in self-directed professional development, teacher-participants were assertive in seeking ways to enhance their professional learning experiences. Self-directed professional development can effect change as reported in the practice of both novice and expert teachers. It would be interesting to know the distinct ways in which self-directed professional development facilitates professional learning and influences practice compared to other forms of professional development.

A careful understanding of how elementary teachers perceive, engage in and understand self-directed professional development is vital, as it provides guidelines on how to support teachers in the quest for ongoing professional development in elementary mathematics education.

7.3 Implications for Policy and Practices

This study on elementary teachers' perception, engagement in, and understanding of self-directed professional development has policy implications. It is evident that the teacher-participants valued several aspects of self-directed professional development, specifically the autonomy that it provides. That autonomy allows them to choose learning activities that fulfill their professional and personal needs and those of their students.

As evinced by the findings of this research, teachers do not have to depend on schools, boards, professional organizations, and the Ministry of Education (MOE) to provide them with opportunities for professional growth. They can seek their own opportunities to enhance their learning and professional growth. When teachers collaborate with their colleagues, connections are made that can result in exciting learning ventures. Such collaboration also promotes collegiality among like-minded professionals and provides them with new teaching strategies they can use in their mathematics lessons.

This study informs the stakeholders in education about the merits of teachers engaging in other forms of professional development. It also highlights the need to

provide means of supporting self-directed professional development among teachers. Self-directed professional development of elementary mathematics teachers could be supported with funding made available at the school, board, MOE, or organizational levels. This research raises several questions about self-directed professional development. The section that follows is a summary of further research inquiry that needs to be done on self-directed professional development.

7.4 Further Research

1. Larger scale research is needed on self-directed professional development to determine the extent to which teachers are engaged self-directed professional development activities and the formats that self-directed professional development is currently taking.
2. More research is needed to investigate the extent to which self-directed professional development impacts student learning in mathematics.
3. The degree to which self-directed professional development, versus conventional forms of professional development, fulfills teachers' professional development needs to be explored in relation to mathematics content.
4. More research is needed to identify specific teacher needs in elementary mathematics education that could potentially be met through self-directed professional development.
5. Comparative studies could also investigate teachers' involvement in self-directed professional development in mathematics and other subjects.

7.5 Personal Reflection

This research grew from my reflection on that sunny Wednesday morning years ago when my students did not understand my explanation of a concept. That experience has sustained my desire to foster teacher professional development. I began my journey in this investigation on self-directed professional development not knowing how the outcome would affect my assumptions about professional development and phenomenography. As a new researcher, I experienced a whole gamut of emotions while involved in this new project. I was excited, scared, fascinated, and humbled during the entire process. My excitement was because I was conducting my first major inquiry and apprehensive because it seemed like a formidable task. Then, I was fascinated in the field as I listened to the experiences of the teacher-participants who enjoyed teaching mathematics and spoke with such passion about their learning and how their practice had changed. I was also humbled as I realized that the teacher-participants' devotion to their professional growth led to a commitment to professional learning and to student learning. This commitment led to an investment of personal time and funds in teacher professional development. Teachers are attracted to professional development because it can contribute to their growth and enhance their practice. The educators I met in this research had that perspective of contributing to their learning and that of their students.

Emerging from my experience in this research is an understanding that the elementary teachers who participated in the study were very passionate about their jobs and careers. They considered teaching and learning of mathematics to be essential in schooling. The level of commitment described by the teacher-participants indicated to

me that teachers were resolute in their determination to foster their own learning and that of their students.

The surprising aspect of this research related to the unanimous opinion of the teacher-participants about the importance of self-directed professional development and the flexibility it affords them. I have grown as a researcher during this journey as I have become more aware of the nuances of professional development that teachers navigate to enhance the classroom experience. The teacher-participants in this study are clearly strong adherents to the ideals of professional development as set out by the Ontario College of Teachers (OCT). They have engaged in numerous ways to enhance their learning and that of their students. The teacher-participants' descriptions of their engagement with self-directed professional development was a confirmation that teachers' vision for their professional growth includes transferring learning opportunities into practice.

One of the questions that emerged from this experience is: How can elementary teachers be supported in their quest to facilitate their professional development? This research to some extent addressed that issue. It afforded 10 experienced educators the opportunity to describe how their professional development activities prepared them to use a variety of teaching methods to teach mathematics in meaningful ways. Professional development of the teacher and its relationship with students' learning is complex because there are many factors to consider. While this investigation focused on self-directed professional development, I am aware that there needs to be an alignment of teachers' needs, mathematics content, and the support they require to maximize their

professional learning needs and that of their students. In retrospect, I thank John, the boy who facilitated learning in my class years ago, for sending me on a journey of self-directed professional development.

7.6 Conclusion

The purpose of this research was to understand how elementary teachers perceive, engage in, and understand self-directed professional development in mathematics education. The researcher sought to investigate elementary teachers' participation in self-directed PD and by doing so contributed to the literature on self-directed PD and phenomenography in mathematics education, in addition to providing insights on how to support professional development that is self-directed.

Ten elementary school teachers were recruited to participate in the study using purposeful sampling. These teacher-participants included practicing teachers who were both female and male as well as both novice and expert. They all professed a passion for teaching mathematics. Ten individual and one focus group interview were conducted in the province of Ontario, Canada.

The principle undergirding this research was the notion that professional development of the teacher plays a significant role in the career of the teacher who is entrusted with helping students develop helpful attitudes towards, knowledge of, and understanding of school subjects. I also saw the goal of teacher professional development as providing teachers with an awareness that their role in the classroom does not end after the lessons are taught, but rather that they are builders of future

generations. In addition, the teachers are seen to support and challenge students to reach their potential and encourage learners to seize multiple opportunities for learning. I used mathematics education as the case for this study because of my own interest in the teaching and learning of mathematics.

Given Chapman's (2013) premise that self-directed professional development can transform teachers' mathematical thinking, it is important for organizations responsible for providing professional development for teachers to consider how they might facilitate self-directed professional development. The findings of this research show that self-directed professional development, as a form of professional development, has merit. It also complements traditional professional development programs, most of which are in the form of mandated professional development. There are benefits to be derived from teachers engaging in self-directed professional development as proved by teacher-participants' reports on their learning and the changes they experienced in their classrooms. The changes made by teacher-participants enabled them to choose a variety of ways to approach mathematics teaching. The result of teachers' engagement with self-directed professional development is that both teachers and students are recipients of the benefits of this form of professional development. The variation in teacher-participants' experiences with self-directed professional development as seen in the outcome space suggests that self-directed professional development has potential to foster teacher growth in their thinking and practice in elementary mathematics education.

The findings of this study indicate that self-directed professional development provides authentic and meaningful experiences for teachers. The transformative nature of

self-directed professional development resulted in reflective practice that allowed the teacher-participants to value the unique talents and needs of their students and to value themselves as individual professionals capable of designing their own teaching excellence (Swain, 1998). The findings of this research offer a perspective on professional development based on the teachers' engagement in self-directed professional development and contributes to the dialogue on professional development of elementary mathematics teachers.

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Appendices

Appendix A. Letter of Information

Project Title: Self-Directed Professional Development in Elementary Mathematics Education

Principal Investigator: Dr. Immaculate Namukasa, Faculty of Education, Western University

Co-Investigator: Chloe Weir, PhD Student, Faculty of Education, Western University

1. Invitation to Participate

You are being invited to participate in this research study on self-directed professional development in elementary mathematics education. Self-directed professional development refers to professional development activities that are initiated by the teacher, for the teacher. This includes individual activities or collaborative efforts with other teachers.

2. Purpose of the Letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

3. Purpose of this Study

The purpose of this study is to find out how teachers perceive, engage in and understand the role of self-directed professional development in elementary mathematics education.

4. Inclusion Criteria

Individuals who teach mathematics in elementary schools are eligible to participate in this study.

5. Exclusion Criteria

Individuals who do not teach mathematics in elementary schools are not eligible to participate in this study.

6. Study Procedures

If you agree to participate in this study, you will be asked to participate in an individual interview and a follow-up focus group session. The focus group session will discuss self-directed professional development in a more detailed manner. This will be done by analyzing the emergent themes that arise from the individual interviews. The individual interview and the focus group session will each last 1 hour. The interview will be conducted at a location convenient to you and the focus group session will be held onsite at Western University. Participants will have the option to participate in the focus group session via Go to Meeting or Skype. These interviews will be audio recorded with your permission.

7. Possible Risks and Harms

There are no known or anticipated risks or discomforts associated with participating in

this study.

8. Possible Benefits

This research provides participants with opportunities to engage in reflection on the professional development activities that are initiated by teachers in elementary mathematics education. Teachers will also reflect on the factors that may promote and foster self-directed professional development.

9. Compensation

You will be compensated for your participation in this research. A gift certificate valued at $25.00 each, tenable at Chapters Book Store, will be given to each participant as a token of appreciation.

10. Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your status as an elementary teacher.

11. Confidentiality

The data collected in this research will remain confidential and accessible only to the investigators in this study. The information collected will be used for research purposes only. If the results are published your name will not be used. * If you choose to withdraw from this study, your data will be removed and destroyed from our database.

12. Contacts for Further Information

If you require any further information regarding this research project or any concerns regarding your participation in this study you may contact Dr. Immaculate Namukasa at 519-661-2111[redacted]us@u[redacted]ir at 905-580-932[redacted]

[redacted]

If you have questions about your rights as a research participant or the conduct of this study, you may contact The Research Office (519[redacted]ail ethic[redacted]

13. Publication

If the results of the study are published, your name will not be used. If you would like to receive a copy of any potential study results, please contact Chloe Weir, Email [redacted]

14. Consent

If you would like to participate in this research, complete the consent form attached and return to me. Alternatively, you may copy and paste and email to me.

This letter is yours to keep for future reference.

Appendix B. Email for Recruitment

You are being invited to participate in a study that we (Dr. Immaculate Namukasa and Chloe Weir) are conducting. This study addresses self-directed professional development in elementary mathematics education. Self-directed professional development is professional development that is initiated by the teacher. This research will offer you opportunities to reflect on your practice. You will be asked to participate in an individual interview and a focus group session. Your time commitment for this study is two hours.

A letter of information is attached. If you would like to participate in this study, please contact the researcher at the contact information given below.

Thank you,

Researcher's name: Chloe Weir

Researcher's affiliation: PhD Student Western University

Researcher's email address: [redacted]

Researcher's telephone number: [redacted]

Appendix C. Consent Form

Project Title: Self-directed Professional Development in Elementary Mathematics Education

Principal Investigator: Dr. Immaculate Namukasa

Co-investigator: Chloe Weir

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's Name (please print): _____

Participant's Signature: _____

Date: _____

Person Obtaining Informed Consent (please print): _____

Participant's Signature: _____

Date: _____

Appendix D. Individual Interview Questions

Experience in teaching mathematics

1. How long have you been teaching at the elementary level?
2. What is the level of your education?
3. What are the grades that you have taught?
4. Have you completed any Additional Qualification courses in mathematics? If yes, what are they?

How would you describe your teaching experience at the elementary level? That is your mathematics teaching experience.

Self-directed professional development:

5. What prompted you to become involved in self-directed professional development?
6. What does self-directed professional development look like for you? Prompt: What activities do you engage in mathematics education that are self-directed?
7. How would you compare mandated professional development with self-directed professional development?
8. After reflecting on your experiences in self-directed professional development in mathematics education, what have you learned about yourself as a teacher? Prompt: Can you identify any personal qualities that you have that is causing you to be involved in self-directed PD in elementary mathematics education?
9. How has self-directed professional development transformed your perception and

thinking about professional development in mathematics education? Prompt: How has your thinking changed?

10. What would you like stakeholders (Ministry of Education, school boards, school administrators, other teachers and parents) to know about self-directed professional development in elementary mathematics education? Prompt-Are there policy changes that you would like to be put in place to facilitate self-directed professional development?

11. How has your practice changed with self-directed professional development? Prompt- what was your practice like before your involvement with self-directed professional development? What is it like now?

Appendix E. Focus Group Interview

1. If you were asked to define self-directed professional development-, what would your definition be?
2. What do you see as the role of self-directed professional development in elementary mathematics education today?
3. How is self-directed professional development in elementary mathematics education transformational in nature?
4. What has been the difference in your approach to teaching elementary mathematics since you have been involved in self-directed professional development?
5. In comparing mandated professional development with self-directed professional development, what would you say are the main differences, if any?
6. What have you learned about yourself as a teacher because of your engagement in self-directed professional development in elementary mathematics education?
7. Reflect on the experiences you have had with self-directed professional development in mathematics education. What would you say is its impact on your practice?

Appendix F. Ethics Approval Form

Research

Western University Non-Medical Research Ethics Board
NMREB Annual Continuing Ethics Approval Notice

Date: April 11, 2017
Principal Investigator: Dr. Immaculate Namukasa
Department & Institution: Education\Faculty of Education,Western University

NMREB File Number: [redacted]
Study Title: Self-directed Professional Development in Elementary Mathematics Education: A Phenomenography

NMREB Renewal Due Date & NMREB Expiry Date:
Renewal Due -2018/04/30
Expiry Date -2018/05/08

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed the Continuing Ethics Review (CER) form and is re-issuing approval for the above noted study.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), Part 4 of the Natural Health Product Regulations, the Ontario Freedom of Information and Protection of Privacy Act (FIPPA, 1990), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

[redacted]
Ethics Officer, on behalf of Dr. Riley Hinson, NMREB Chair

EO: Erika Basile ___ Grace Kelly ___ Katelyn Harris___ Nicola Morphet ✓ Karen Gopaul ___

Curriculum Vitae

Name:	**Chloe Dawn Weir**
Post-secondary Education and Degree	St. Joseph's Teachers' College Kingston, Jamaica Diploma in Teaching
	The University of the West Indies Kingston Jamaica BEd (Hons)
	Northern Caribbean University Manchester, Jamaica MA
	The University of Western Ontario London, Ontario, Canada PhD
Honors and Awards	Art Geddis "Learning about Teaching" Memorial Award 2014-2015
Related Work Experience	Research Assistant, Teaching Assistant The University of Western Ontario 2012-2016
Publication	Namukasa, I. K., Sarina, V., & Weir. C. D. (2016). Manipulatives and Analogies for Teaching Integers: An Example of a Grades 7 and 8 Unit. Ontario Association for Mathematics Education, *55*(2). Weir. C. D. (2017). Self-regulated learning and teachers. Canadian Association for Educational Psychologists Dialogic. https://caepacp.files.wordpress.com/2017/05/dialogic-2016-2017-04-28-1711.pdf