The Teacher’s Role in Problem-solving: A Study of Elementary Mathematics Programs from Teachers’ Perspectives

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Abstract

With an increasing need in Canada to create a labour market that can help to sustain the growing knowledge-based economy, Canadian teachers are being pushed to introduce skills that are needed for students to succeed in science, technology, engineering and mathematics (STEM)-related disciplines (Mishagina, 2012; Orpwood, Schmidt & Jun, 2012). Mathematical problem-solving is one of the fundamental STEM skills introduced to students in the elementary grades. With that in mind, this study examines the role of elementary teachers in implementing problem-solving in the context of their math programs. Using a qualitative research approach, two elementary teachers were interviewed and asked to share their experiences teaching problem-solving in their classrooms. Teachers discussed and revealed practical strategies they used to implement problem-solving tasks. The findings indicated that teachers’ actions before, during and after a problem-solving task greatly influenced the quality of the task. In addition, teachers addressed the importance of creating a classroom environment that encourages students to engage in problem-solving. These findings provide practical ideas that teachers can implement to improve their own problem-solving instruction.

Key Words: mathematics, problem-solving, strategies, teachers, instruction
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The Teacher’s Role in Problem-solving: A Study of Elementary Mathematics Programs
from Teachers’ Perspectives

Chapter 1: INTRODUCTION

1.0 Introduction to the Research Study

Sally and Jim each have a bag of hard candy. Sally said, “Jim, if you give me 5 pieces of candy from your bag, I’ll have as many pieces as you.” Jim laughed and answered, “No, you give me 5 of yours and I’ll have twice as many as you.” How many pieces did they each have to begin with? (Pelfrey, 2000, p. 8)

One might wonder what a question about candies has anything to do with the future outlook of the Canadian economy. The answer lies in problem-solving. How do current educators lead our elementary school students from solving problems about chocolate bars to solving problems about how to make solar energy affordable, prevent nuclear terror and engineer more effective medicines in the upcoming years? Do the 12 years of schooling that students receive within the Ontario education system adequately prepare them to become the professionals tasked with building Canada’s future in the fields of science, technology, engineering and mathematics (STEM)?

As Canada continues to assert itself as a competitor in the global knowledge-based economy, the demand in the STEM professions continues to increase (Jobs Report: The State of the Canadian Labour Market, 2014). Currently, Canadian STEM workers are in shortage compared to other competitive nations such as China and India (Mishagina, 2012). The Canadian government mandates the aim to increase the amount of highly qualified STEM professionals. However, the current shortage of post-secondary students who are majoring in STEM fields are proving to be problematic for fulfilling market demands (Mishagina, 2012). Although Canada performs well in the total amount of post-secondary degrees earned, it performs relatively poorly
against other developed nations in terms of university students who graduate from STEM fields (Jobs Report: The State of the Canadian Labour Market, 2014). This is attributed to the decreasing interest in STEM fields among Canadian youth (Mishagina, 2012). In order for students to continue entering into STEM fields, students need to first develop the skills they need to succeed in them. Some of the major qualifying skills include innovation, critical thinking and problem-solving (Innovation Generation, 2014). This means that in order to achieve the goals set by the government, Canadian educators need to teach today’s children the important skills that they need for future job markets.

In order to adequately understand and address Canada’s STEM professional deficiency, it is important to study and analyze every aspect of the problem to find possible reasons and solutions. This study contributes microscopically to the complex and comprehensive understanding of current issues in the Canadian labour market. In particular, it examines the ways in which problem-solving is being taught in elementary grade mathematics.

Problem-solving is defined as “mathematical tasks that have the potential to provide intellectual challenges for enhancing students’ mathematical understanding and development” (National Council of Teachers of Mathematics, 2010, p.1). Throughout the years, mathematicians and math educators have formulated many perspectives with respect to problem-solving in math education. Problem-solving has progressed through centuries of pedagogical change, but the debate goes on as how to best fit it into the math classroom (D’Ambrosio, 2003). From the mid-1850s to the 1980s, the dominant view of educators was that teaching math involved first showing students a new mathematical concept, followed by students applying that concept using problem-solving tools such as word problems (Ray, 1877). In this sense, the act of problem-solving was isolated from the actual mathematical teaching of concepts. During the late
twentieth century, mathematics education became a more credible field in university programs, which brought on a change in conventional ideologies of teaching math (D’Ambrosio, 2003). One drastically differing view that emerged was the idea of teaching mathematics through problem-solving (Lester & Mau, 1989). This view asserted that problem-solving could be used as a vehicle to drive the teaching of new mathematical concepts (Stanic & Kilpatrick, 1988).

Along with presenting a new stance, Stanic and Kilpatrick (1988) also developed three problem-solving themes that helped to conceptualize the theoretical framework of how problem-solving is perceived. One theme viewed problem-solving as context, whereby the process of solving problems was used to achieve alternative objectives. Such objectives included problem-solving as justification, problem-solving as motivation, problem-solving as recreation, problem-solving as vehicle and problem-solving as practice. The second theme viewed problem-solving as a skill that needed to be taught in the curriculum. This view perceived problem-solving as a skill that was needed to succeed in solving real-world problems. The third view depicted problem-solving as an Art (Stanic & Kilpatrick, 1988). This view was oriented from the work of George Polya (1957), who revolutionized the perceptions of problem-solving in the twentieth century. He proposed that mathematics should be taught in a way through which students got the opportunities to create mathematical discoveries themselves (Polya, 1957). Through these themes, it is evident that different educators see problem-solving as having different functions and should be taught in different ways.

1.1 Purpose of the Study

The purpose of this study was to investigate the possible discrepancies between theoretical understandings of problem-solving and the implementation of problem-solving in classroom settings. Despite the fact that a lot of research has been conducted on how students
engage in problem-solving, it is still unclear how teachers implement and assess the development of problem-solving competences of their students (Santos-Trigo et al., 2014). This study examined the ways in which elementary school teachers incorporated problem-solving in their math programs to provide insights on how to improve current problem-solving instruction.

Problem-solving takes up an important place in the field of mathematics and math education. Firstly, it is important to examine the most effective method to teach problem-solving because from a pure mathematics perspective, problem-solving promotes conceptual understanding (Lambdin, 2003). The primary goal of teaching mathematics is for understanding. However, understanding cannot be taught directly, because it is an internal and unobservable phenomenon; it occurs when students’ minds integrate new information with previous understandings. Teaching problem-solving is a powerful way to promote this kind of thinking (Lambdin, 2003). Secondly, from an applied mathematics perspective, learning more effective ways to teach problem-solving helps students to learn different applications of mathematics and to make the mathematics learning process more interesting (Santos-Trigo, 2014). This can help to increase students’ skills and motivation for learning mathematics. It also helps students to learn the skills they need to further build on necessary knowledge for contributing to STEM fields in the future (Binkley et al., 2012).

There are several factors that contribute to the importance of the present study. Many studies conducted about problem-solving take a very theoretical-to-practical perspective, whereby researchers investigate the effects that problem-solving has on a certain math program or on student achievement, and then make theoretical extrapolations without consideration for the practical contributions of the study. There is a lack of research studies done that focus on immediate practical experience of teachers in real-world classrooms and on how their
perspectives can contribute to the understanding of useful problem-solving skills. These practical insights may help researchers to gather and extrapolate further theoretical understandings. The present study attempted to bridge this gap in the literature by adhering to qualitative methods. This way, the practical experiences of teachers were personalized and not overshadowed by the statistics of quantitative studies. Using qualitative research design provided the outlet to analyze and discuss both the components of mathematical thinking and the process in problem-solving strategies (Santos-Trigo, 2014).

This study used qualitative research design to support people to make personalized individual accounts. It was conducted through a case study format. There were two case studies conducted. Interviews were performed during each case. Each case consisted of interviewing a teacher for around half to one hour about their experiences with teaching problem-solving in their math programs. The teachers needed to have had elementary teaching experience of at least three years. The qualitative nature of this study allowed for optimal grasp of teachers’ personal experiences and individual insights on problem-solving in math education.

The case study design gave the opportunity for the researcher and the participant to develop a more authentic and organic relationship for knowledge building. As this study was intended to use the teachers’ practical skills to inform the researcher of insightful theoretical underpinnings, the case study was able to provide exactly that. It allowed for an in-depth extrapolation of quality knowledge from qualified contributors (Creswell, 2013). An example of a successful study that was also conducted using the same research design helps to support the suitability of this research design choice: Tripathi (2009) uses a case study method to determine whether problem-solving can be used to change the attitude and beliefs about mathematics and what strategies may teachers use to enhance mathematics learning. Tripathi’s study was able to
grasp at the personal insights from students and teachers due to its qualitative case study method selection (Tripathi, 2009). Similarly, the present study also determined the strategies and experiences of teachers.

1.2 Research Questions

The central question of my research study is what roles and strategies do elementary teachers use in implementing problem-solving in their math programs? In connection to that, my subordinate questions are: What are teacher perceptions of the role problem solving plays in their elementary math programs? What strategies do teachers feel are useful in implementing problem solving in their elementary math programs? How do teachers describe their roles before, during and after implementing a problem-solving activity? How do teachers create sociomathematical norms for problem-solving in their classrooms? How do teachers view the practical usefulness of theoretical models of problem solving as applied in the classroom?

1.3 Background of the Researcher

The idea for this study first came into my mind during my first practicum. I had the opportunity to join in on one of the staff division meetings for teachers from Grades 1-3 at my practicum school. During the meeting, one of the teachers initiated a conversation about the Canadian government’s mandate about producing more STEM professionals in the future. This started a discussion amongst the teachers about the skills that they thought their students lacked and needed further development in. One of the skills they mentioned was problem-solving. This got me to think about why and how problem-solving skills could be better implemented in elementary math programs.

This topic is important to me because I have had a very mercurial relationship with mathematics in my K-12 education. I completed my kindergarten to Grade 3 in China, where I
had a very different math experience than when I came to Canada. This got me to think about how there are so many different approaches to teach math, how is one supposed to know which is more effective than the other? For example, I remember when I learned math in China, there was a lot of homework assigned with math lesson that consisted of hundreds of practice problems that seemed very repetitive. However, in China I was also presented with many more challenging math problems to solve. While in Canada, teachers seemed to incorporate less rote memorization, but also less challenging problems as well. In China, there was also an academic culture where everyone was expected to work very hard in school. Almost all students were expected to complete challenging math contests and many parents signed their child up for mathematics Olympiad prep courses, even in the elementary grades. In Canada, I found that it was only the identified advanced students who received more challenging math problems. This cross-cultural educational discrepancy on mathematics problem-solving also contributed to my interest in this area of educational research.

1.4 Overview

Chapter 1 includes the introduction and purpose of the study, the research questions, as well as how I came to be involved in this topic and study. Chapter 2 contains a review of the literature on this topic. Chapter 3 provides the methodology and procedure used in this study including information about the participants, data collection instruments, and limitations of the study. Chapter 4 identifies the research participants and describes the data as it addresses the research questions. Chapter 5 includes what was learned, insights, recommendations for practice, areas for further study, and a review the limitations of the study. References and a list of appendices follow at the end.
Chapter 2: Literature Review

2.0 Purpose of the Literature Review

It has been widely accepted by mathematics educators that the development of students’ problem-solving abilities should be a primary objective of mathematics instruction, and that problem-solving should play an integral role in the curriculum of mathematics programs (Lester, 1994). The importance of problem-solving is shown through the fact that it has been one of the most written-about areas of study in mathematics education for the latter part of the twentieth century (Lester, 1994). However, this does not mean that topics in problem-solving are well understood, nor does it mean that educators, mathematicians and researchers have reached consensus and understanding of how problem-solving should be taught to students (Lester, 1994).

In fact, there has been so much disagreement amongst mathematics scholars in the problem-solving field that even the most basic consensus of the definition of the terms “problem” and “problem-solving” cannot be achieved (Heller & Hunigate, 1985; Schoenfeld, 1992; Lester 2013). For the intent of clarity and generalizability, Lester (2013) summarizes the used definitions of the term “problem” with two prevailing ingredients. The first ingredient is that there is a goal, and the second ingredient is that the individual (i.e. the problem solver) is not immediately able to achieve the goal (Lester, 2013). Similarly, Lester and Kehle (2003) attempted to capture an integrated definition of the term “problem-solving” after considering an abundance of definitions in the literature. They said that successful “problem-solving” involves:

> Coordinating previous experiences, knowledge, familiar representations and patterns of inference and intuition in an effort to generate new representations and related patterns of inference that resolve some tension or ambiguity … that prompted the original problem-solving activity (Lester & Kehle, 2003, p.510).
Although these definitions may be more precise for the purpose of specific research analysis, this literature review uses the terms “problem” and “problem-solving” to mean the broadest sense of the words, in order to encompass multiple understandings of the terms.

As was demonstrated with the conflicting meanings of the two terms above, there is much discrepancy amongst problem-solving researchers on various debated topics. The purpose of this literature review is to provide a succinct overview of problem-solving research through 1) a brief summary of the changing perspectives throughout the years, 2) a discussion of prominent research themes, 3) an analysis of current issues in problem-solving research and 4) the examination of currently underrepresented themes and needed directions for future research. Through these areas of discussion, this literature review will reveal the contextualized purpose of this current research study, which is to determine how problem-solving is currently being implemented by teachers in elementary math programs.

2.1 An Overview of Problem-solving Research throughout the Past 50 Years

2.1.1 The Pendulum Swing in Mathematics Education

The mathematics curriculum in the United States received little attention up until the latter part of the twentieth century (Schoenfeld, 2007). It was also during this time that mathematics education research became more accepted as a legitimate field of study in university academia (D’Ambrosio, 2003). Since then, many areas of mathematics education have been researched with varying significance and impact to the field. Problem-solving was amongst one of the areas studied.

One major factor that has impacted the quality and quantity of problem-solving research throughout the past half century is the 10-year cycle of the pendulum swing. In North America, the field of problem-solving experienced paradigm shifts about every 10 years or so. The cyclic
trend drifted between emphasis on teaching basic mathematic skills and doing problem-solving (Schoenfeld, 1992). In the 1970s, the pendulum was heavily swung towards teaching basic skills. This was a result of backlash from the failed attempt of the “new math” curriculum developed by the United States in the 1960s in an effort to catch up to the Soviet Union’s technological developments as epitomized by the launch of the satellite *Sputnik 1* (Schoenfeld, 2007). During this time, American – and to an extent Canadian – math classes were focused on pure mathematical concepts taught using a rote “basics” approach (Schoenfeld, 2007). In the 1980s, the National Council of Teachers of Mathematics (NCTM) launched *An Agenda for Action*, which states that “problem-solving should be the focus of school mathematics” (NCTM, 1980, p.1). This launched the pendulum shift, making the 1980s the “decade of problem-solving” (Lester, 1994, p.661). This paradigm shift stimulated a surge of problem-solving research (to be discussed later in this chapter).

By the beginning of the 1990s, the U.S. and many other countries had begun to shift back towards teaching mathematics with a strong emphasis on basic skills. This pendulum shift was heavily motivated by the beginnings of worldwide preoccupation with standardized testing (Lesh & Zawojewski, 2007). Problem-solving researchers are currently debating whether the paradigm is once again going to shift back to the emphasis on teaching problem-solving (Lester, 1994). Some propose evidence that problem-solving research has declined significantly post the 1980s and has not resurged since (Lester & Kehle, 2003; Stein, Boaler, & Silver, 2003). Nevertheless, others argue that the pendulum is shifting back towards an emphasis on problem-solving as a result of the new research emphasis on applied mathematics (Hall, 1999; Noss, Hoyles, & Pozzi, 2002). Still others argue that problem-solving research has declined post-1980 due to the fact
that researchers have compartmentalized and disguised it into new areas of research, such as student discourse in mathematics (Lester, 2013).

Regardless of whether another paradigm shift is approaching, the important issue to note is that even though there are cycles of pendulum swings that are occurring, the review of the literature compared over these cycles indicates that few knowledge gains are being made from one cycle to the next. For example, when Frank K. Lester, Jr., a prominent researcher who has studied in the field for 40 years, compared the lists he made on issues in problem-solving research in 1980, 1994, and 2003, there was astonishingly little progress to be seen in the research and the literature on problem-solving implementation in school practice (Lesh & Zawojewski, 2007).

2.1.2 The Changing Nature of Research Emphases and Methodologies

Although the research on mathematical problem-solving has been criticized throughout the years for being unsystematic, restricting in problem type and lacking in theoretical foundation (Begle, 1979; Kilpatrick, 1969, Silver, 1985; Lester 1994), there is no doubt that the nature of its research has matured tremendously in its short existence (Lester, 1994). From the 1970s to 1990s, different problem-solving aspects became emphasized through research and different research methodologies were explored.

Research and methodology emphasis during 1970 – 1982. During this period, research focused on the isolation of key determinants of problem difficulty and identified characteristics of successful problem-solvers (Lester 1994). Golden and McClintock (1984) focused exclusively on features of the types of problems students were asked to solve during school and found four tiers of variables that contribute to problem difficulty. These consist of content and context variables, structure variables, syntax variables and heuristic behaviour variables (Golden &
These early research works in problem-solving were critiqued and viewed with much skepticism. Kilpatrick (1985) criticizes the study for not having any purpose other than demonstrating that measuring task variable is easily quantifiable. Furthermore, some important variables relevant to problem-solving research were ignored, and the problem-solving situations did not go beyond the walls of the classroom (Lesh & Zawojewski, 2007). The methodology of choice during this time period was linear regression modeling (Lester, 1994). This was an initial attempt to make mathematical problem-solving research more systematic and quantifiable (Lester, 1994). This methodology was later replaced by information-processing techniques. The complexity was eventually added to this area of research through investigations of the interaction between task variables and the characteristics of the problem solver (Kilpatrick, 1985). Today, there is general agreement that problem difficulty is influenced more so by the characteristics of the problem-solver (i.e., traits, dispositions, and experiential background), rather than the task variables (Schoenfeld, 1992).

**Research and methodology emphasis during 1978 – 1985.** One predominant research focus during this time period was individual problem-solving competence and performance (Charles & Silver, 1988). Researchers compared and observed distinctions between successful and unsuccessful problem-solvers. Lester (1994) summarized five key areas in which “expert” problem solvers excelled more than “novice” problem solvers. Many of these studies were done through case studies and the “think aloud” protocol analysis (Lester 1994). Another area of focus in the literature during this time was in regards to problem-solving instruction. At the time, many problem-solving programs were initiated, but few were evidence-based (Lester, 1985). Although literature on problem-solving instruction presents ambiguous arguments, Lester (1994) concludes
five important research findings. More discussion about problem-solving instruction will be discussed later in this review.

**Research and methodology emphasis during 1982 – 1990.** Metacognition was the main area of focus in the latter part of the 1980s. Researchers considered three main components of metacognition during problem-solving. These were a) knowledge of one’s own thinking processes, b) regulation and monitoring of one’s actions throughout a problem-solving task and c) beliefs and intuitions (Schoenfeld, 1992). Lester (1994) summarizes three results that have been well-researched about how metacognition influences problem-solving. Metacognition is one of the forces that drives successful problem-solving (Garofalo & Lester, 1984). However, the degree to which metacognition impacts problem-solving activity is still unresolved, and most importantly, the ways in which teachers can develop students’ metacognitive skills is still unknown (Lester, 2013).

**Research and methodology emphasis 1900 – onwards.** Problem-solving research flourished in North America during the 1980s and the beginning of the 1990s and decelerated in the mid 1990s. Lester (2014) considers several explanations for this decline. One possible explanation is that other issues in mathematics education have drawn attention away from problem-solving. Another explanation is that many math educators began to subscribe to the increasingly dominant ideology of constructivism and discerned uninformed assumptions that problem-solving and constructivism are interchangeable positions (Lester, 1994). Despite this decreased focus in the literature, continued progress was made (Schoenfeld, 2007). Over the 1990s and into the twenty-first century, researchers advanced methodological tools, techniques and eventually transformed the study of problem-solving into new and unexplored mathematical understandings (Schoenfeld, 2007).
2.2 Literature on Problem-solving Instruction

2.2.1 Overview of Problem-solving Instruction

Most math curricula across North America devote some part of their curriculum guidelines to addressing the importance of teaching problem-solving to students. However, the ways in which problem-solving can be incorporated as an integral part of the curriculum remains very unclear (Lester, 1994). Rather than providing teachers with coherent directions to guide problem-solving instruction, teachers are often left to their own devices, which often results in a well-intentioned attempt to teach story problems through very rigid and inflexible ways (Lester, 1994). For instance, The Ontario Curriculum Grades 1-8: Mathematics (Ontario Ministry of Education, 2005) devotes seven pages of its introduction to the discussion of “The Mathematical Processes” (p. 11). Of those, two pages are used to discuss the importance of problem-solving, problem-solving strategies and the George Polya’s Four-Step Problem-solving Model. After the introduction, problem-solving is mentioned at the beginning of each grade as part of the Mathematical Process. The curriculum document makes no suggestions to teachers as to how problem-solving should be incorporated or taught. Thus, there are many issues about learning, instruction and assessment that need to be addressed (Lester, 1994).

2.2.2 Problem-solving Themes

Many perspectives exist during the discussion of the most appropriate approach for problem-solving instruction. Before those perspectives can be discussed, it is necessary to discuss several problem-solving themes in order to contextualize the way in which these perspectives fall into the broader perspective. Stanic and Kilpatrick (1988) have generated three general themes that characterize the role of problem-solving in mathematics learning: problem-solving as context, problem-solving as skill and problem-solving as art. The context theme
includes subthemes, such as problem-solving as justification ad problem-solving as vehicle, but all have the underlying intent to use problem-solving to achieve other valuable ends. Problem-solving as skill sees problem-solving as a number of skills to be instructed the school curriculum. Through this perspective, problem-solving is not necessarily a content area, but rather a skill to be learned. The final theme sees problem-solving as art in that it is a comprehensive view of problem-solving in the curriculum (Stanic & Kilpatrick, 1988).

2.2.3 Polya’s Problem-solving Strategies and Model

George Polya (1945)’s publication of “How to Solve it” influenced many problem-solving perspectives after its publication. It greatly impacted the problem-solving “movement” of the 1980s (Schoenfeld, 1992). Polya’s model became one of the predominant approaches to guide teaching strategies during the 1970s, 80s and today (Santos-Trigo, 2007). Polya-style problem-solving strategies consisted of teaching direct instruction to students about problem-solving strategies, heuristics (self-teaching) and the well-known four-step problem-solving model, which is used in the Ontario Mathematics Curriculum (Polya, 1957; Ontario Ministry of Education, 2005). The four-step model consists of understanding the problem, making a plan, carrying out the plan and looking back to check the results (Polya, 1957).

Despite the fact that discussions of Polya’s work can be found in abundance in mathematics education research articles (e.g., references), there is much criticism that is associated with this perspective. One major critique of Polya’s heuristic model is that the strategies used are for the purpose of helping problem-solvers think, reflect and find alternative solutions to a completed problem rather than helping a problem-solver who is stuck during the solution process (Schoenfeld, 1992). In addition, Wilson (1967) and Smith (1973) found that Polya’s heuristics approach did not transfer to new domains; rather, it positively correlated with

**2.2.4 Teaching Domain- General vs. -Specific Problem-solving Strategies**

Domain-general problem-solving strategies are mental computations developed by the problem-solver that are activated on a group of related problem tasks (Owen & Sweller, 1990). These general tasks are similar to the four-step model proposed by Poyla (1957) in that the steps or strategies learned are generalizable to multiple problems. Charles and Lester (1984) studied the result of both domain-general and -specific strategies and found that the experimental domain-general group performed better. Additionally, transfer and generalization skills were enhanced (Cooper & Sweller, 1987). However, scholars dispute the effectiveness of domain-general strategies by stating that there is very little overall evidence to show the success of teaching general problem-solving techniques (Sweller, 1990).

**2.2.5 Varying Perspectives on the Goal of Problem-solving**

Two perspectives on problem-solving instruction can be applied to the problem-solving themes just mentioned above. The debate over the benefits of teaching direct instruction vs. the constructivist instruction has gone on for many years (Lester, 2013). These varying perspectives affects the ways in which mathematics programs are set up and they influence the method of problem-solving instruction in those classrooms.

The main distinction between the two prevailing perspectives is the goal that is aimed to accomplish during a problem-solving task. If problem-solving is intended as the end result of instruction, then students learn about problem-solving. However, if problem-solving is the means through which mathematical concepts are learned, then students learn via problem-solving (Lester, 2013). This new perspective in problem-solving instruction was developed at the wane
of the 1980s and is now commonly known as teaching mathematics via/through problem-solving (Lester & Mau, 1993).

2.3 Underrepresented Themes and Needed Directions in the Literature

While the field of problem-solving in mathematics education have received more attention and provided more valuable information about problem-solving instruction, there is still endless work to be done (Lester, 2013). This literature review gave a brief overview of the status of problem-solving research for the past half century. And through this literature stroll, it is evident that certain areas of research are still underrepresented in the accumulating scholarship. These will be discussed presently.

2.3.1 The Role of the Teacher in Problem-solving Instruction

In comparison to the quantity of problem-solving research in mathematics education, the amount of problem-solving instruction research is few and far between (Thompson, 1989). Amongst it, research on how teachers impact problem-solving instruction is scarce (Silver, 1985). Typically, research in problem-solving instruction describes instructional methods in general ways and neglects to mention the teacher’s specific role (Lester, 2013). Silver (1985) states that as ironic as it may be, teachers are the “forgotten soul” (p. 262) in research on teaching and learning of mathematical problem-solving. Teacher and teacher-related variables are often controlled as extraneous variables or unconsciously ignored by researchers (Silver, 1985). It has been demonstrated in many studies that teachers’ beliefs, understandings, conceptions, and knowledge about mathematics profoundly impact their behaviour and consequently the learning of their students (Thompson, 1982; Silver, 1985). In order for problem-solving instruction to be effective, teachers’ roles need to be considered.
2.3.2 Classroom Problem-solving Ecology

Silver (1985) asks what happens in classrooms where mathematical problem-solving is taught well – what factors in a classroom contribute to students’ problem-solving instruction and learning. Silver (1985) admits that there lacks research to address these questions. Overall, there is a lack of descriptive accounts of teachers’ behaviours, teacher-student and student-student interactions and the type of sociomathematical norms that are created to ensure a problem-centered atmosphere for students (Silver, 1985; Lester, 2013).

2.4 Current Research

From the literature review, two underrepresented themes emerged in the literature that will be addressed in this study. The first underrepresented theme being the role of the teacher in problem-solving instruction, and the second underrepresented theme being classroom problem-solving ecology. It is evident that qualitative methodology in problem-solving research can be beneficially used to investigate these relevant gaps in the literature. This study will investigate the roles in which teachers perceive, act and reflect on their understanding and implementation of problem-solving instruction. It will also investigate how teachers nurture a problem-centered atmosphere in the classroom in order to encourage problem-solving. Additionally, a look at how theoretical understandings contribute to teacher practice in problem-solving instruction will also be investigated. The main research questions asked by the present study is:

- What strategies do elementary teachers use in implementing problem-solving in their math programs?

This is followed by five subsequent questions:

- What are teacher perceptions of the role problem solving plays in their elementary math programs?
What strategies do teachers feel are useful in implementing problem solving in their elementary math programs?

How do teachers describe their roles before, during and after implementing a problem-solving activity?

How do teachers create sociomathematical norms for problem-solving in their classrooms?

How do teachers view the practical usefulness of theoretical models of problem solving as applied in the classroom?

These questions will guide us forward in examining the design, methodology and participant search of this study, which will be detailed in the following chapter.
3.0 Introduction

Given that the objective of this research study is to understand roles the teachers play in implementing problem-solving in elementary math programs, it is of interest to discuss the research methodologies employed. This chapter begins with a discussion of the present study’s general research approach and an outline of its procedures. This is followed by an overview of the data collection process. Next, the participant criteria and characteristics are discussed, followed by the data analysis and ethical review procedures. This chapter concludes with a discussion of the methodological limitations and strengths of the current research study.

3.1 Research Approach & Procedures

This research study used a qualitative research approach to examine the key components of teacher’s experiences in conducting problem-solving. This qualitative approach involved conducting a literature review that provided an overall view of the current research findings with regards to problem-solving in math. Then, two semi-structured interviews were conducted with teachers in the elementary grades. Qualitative design was used because this type of research method has several important features that corresponded well with the nature of this research study. First, qualitative design can often help to generate hypotheses for future studies (Glaser & Strauss, 1967). One pertinent goal of this research study was to use the practical classroom experience of the participants to benefit theoretical developments in how problem-solving can be used effectively in elementary math classes. The intent of this study was also to complement many of the quantitative research studies that have been done about the effects of math problem-solving, by adding teachers’ perspectives. Thus, this qualitative study design can be used to help supplement many quantitative research findings (e.g., Dunn, 1983).
3.2 Instruments of Data Collection

The instruments of data collection in this research study were semi-structured interviews. This interview method is primarily used in qualitative research methodology to enhance the collection of individuals’ unique experiences (DiCicco-Bloom & Crabtree, 2006), which is well in conjunction with the goals of this research study. While most interview questions in this type of interview are predetermined, dialogue form is often used to make the questioning method seem more conversational; other spontaneous questions may also arise during the discourse (DiCicco-Bloom & Crabtree, 2006). In this particular study, a single interviewee was interviewed at a time.

The semi-structured interview is appreciated by many qualitative researchers for its flexible and accessible nature (Qu & Dumay, 2011). For this study in particular, the semi-structured interview method was open-ended enough for teachers to share their personal experiences and expertise in the field of problem-solving instruction, yet still guided enough that each teacher stayed on the topic of problem-solving instruction. Since the ways in which individual teachers run their math programs vary, each teacher has their own, unique perspectives about effective strategies for teaching problem-solving. Additionally, since the topic of problem-solving can be very broad, it can be overwhelming for a teacher to talk about it as a whole. Semi-structured interviews can alleviate interviewee stress by providing organized and open-ended questions to guide teacher responses, so they stay on topic (Qu & Dumay, 2011).

3.3 Participants

This section establishes the parameters for participant selection. It begins with a discussion of the sampling criteria for participant selection, followed by an overview of how participants were recruited. This section ends with a brief autobiographical description of each of
the participants in the study, thereby developing an understanding of each participant’s teaching experience.

### 3.3.1 Sampling Criteria

Several criteria for participant selection were imposed in order to obtain relevant results. The first criterion dealt with the general teaching experience of the teacher-participant. Since the research question asked teachers to share their experiences in regards to the ways in which they implemented problem-solving in their math programs, teachers needed to have a minimum of three years’ classroom teaching experience. This way, participants demonstrated some experience in being a classroom teacher. The second criterion required participants to have experience in teaching in the elementary grades. Teachers’ experience in elementary-level teaching ensured their insights on problem-solving instruction for those grade levels. The third criterion was that teacher-participants should show some form of expertise in math problem-solving education. This could come in many forms, e.g. having an Additional Qualification in math, having a graduate degree in math education, or simply having taught elementary mathematics in the classroom for more than three years. The last criterion for participants was that they should have conducted problem-solving tasks regularly in their classrooms. Since the central theme of this research project was to learn from teacher experiences with problem-solving tasks, teachers must first have conducted problem-solving in their own classrooms in order to share those experiences.

### 3.3.2 Sampling Procedures

This study was conducted as part of a two-year Masters of Teaching program with a partial research focus. Due to its limited time and resource availability, the participant samples were collected through convenience sampling. This technique is a less rigorous technique than
other types of sampling, such as judgment sampling or theoretical sampling (Marshall, 1996). For participant recruitment, I contacted teachers in the Toronto District School Board (TDSB), where I did most of my practice teaching training. I also asked professors at the Ontario Institute for Studies in Education for suggestions in whether they knew of any suitable candidates. Teachers were always asked to participate voluntarily and with written consent, to ensure they do not feel pressured or coerced into participating.

3.3.3 Participant Biographies

Teacher A has taught for 10 years, the majority of which have been in Kindergarten. She has also taught special education, Grade 2 and some junior grades. Furthermore, she coached teachers about implementing inquiry-based programs into the Kindergarten program during professional development sessions. In her Kindergarten program, she consistently used problem-solving tasks in the math tasks that she facilitated.

Teacher B has taught for 7 years, for two of which she has been on maternity leave. She focused on teaching Grades 4, 5, 4/5 split, Senior Kindergarten and Grade 1/2. She completed her undergraduate degree in French, which also allowed her to teach French Immersion math classes. During her teaching, Teacher B has implemented problem-solving regularly in her math programs.

3.4 Data Analysis

Because this research study focused on the study of teacher experiences, it was open-ended in nature. This made it imperative for the data analysis process to carefully examine the important themes in participants’ responses. This process involved the organization of data, the coding and finding of common themes, the representation of data and making informed interpretations of the themes (Creswell, 2013). Creswell (2013) has stated that this process often
presents itself in spiral form, where data often goes through analysis multiple times before a concrete interpretation can be made. So, after the interview process was completed, all audio-data was transcribed, coded according to various categories and analyzed for similar themes. Null data is also an important part of the information analysis (Creswell, 2013). Possible omissions made by teachers could indicate important gaps in the articulation of problem-solving instruction. After this spiral process, interpretations about effective ways in which teachers teach problem-solving were revealed.

3.5 Ethical Review Procedures

This study was intended to give teachers an opportunity to share their expertise from their experiences, which mostly entailed a sit-down discussion format interview. While this was a low-risk study, several concerns arose. In terms of confidentiality, all participants were given pseudonyms, though they had the option to use their official names if they so desired. All identifying markers – including school names, personal information markers and student information – were excluded to ensure anonymity. All recorded interview data consisted of audio recordings in MP3 format and was stored in a laptop/computer that was password protected. This data would be destroyed after 5 years of completing the study. Participants were given a consent letter (see Appendix A), which would indicate their consent to be interviewed and audio-recorded. This letter clearly stated the overall intent of the study, addressed any ethical implications and outlined all expectations of participation. Participants also had the opportunity to review the recorded transcripts after the interview, and choose to refrain from answering a question or withdraw from the study at any time. Prior to the study, participants also received a copy of the interview questions to help them feel more comfortable with the interview situation (Creswell, 2013).
3.6 Methodological Limitations and Strengths

As with all research studies, several methodological limitations were present. Firstly, it is important that the reader understands that the purpose of this study was to delve into individual teachers’ experiences with regards to problem-solving instruction. This study was not intended for the generalization of methods to teach problem-solving. This is a qualitative study with a small sample size, so generalizability is extremely weak. Secondly, The MTRP’s ethical protocol was limited to interviewing teachers. While teachers can provide a vast amount of information about their instruction methods, there are other members of the educational community that can also provide valuable information, but are excluded from this study due to limited ethical permissions.

With that said, this study also had several strengths. Firstly, the qualitative characteristics of this study allowed for greater depth in the sharing of individual experiences. Additionally, this in-depth understanding from teacher experiences gives future researchers the opportunity to construct theories about the benefits of problem-solving instruction on teaching mathematics. Also, this research study helps fill the gap for the lack of research studies that discuss problem-solving instruction, as most of the problem-solving studies in the literature focus on the effects of problem-solving rather than the instructional process (Lester, 2013).

3.7 Conclusion

In this chapter, I discussed the general research approach of this study, as well as the detailed intents of how the study was conducted and analyzed. I ended this chapter with a discussion about ethical procedures and the present study’s methodological strengths and weaknesses. In the next chapter, I will report my research findings.
Chapter 4: Research Findings

4.0 Introduction

With the data collection completed, this chapter analyzes and discusses the major findings that originated from the two interviews conducted for this study. To reiterate, this qualitative study examined teachers’ experiences and perceptions of the role they play in implementing problem-solving in their math programs. In particular, teachers discussed their perception of the place problem-solving has in mathematics education, the strategies they use for implementing problem-solving tasks, and how they think theoretical frameworks impact problem-solving instruction in the classroom. The interviewees who shared their experiences were two elementary teachers from the city of Toronto. They each brought in their unique experiences, as well as their opinions about problem-solving instruction. Their voices were important to this research study because they brought to life the personal experiences of committed educators who have brought problem-solving into their classrooms.

After going through the method (as detailed in Chapter 3), this study proceeded to code the transcripts from the two interviews. Subsequently, the study extrapolated the important concepts and categorized them into major themes. Five major themes will be highlighted for discussion in this chapter, and these include: 1) Teachers’ plans before Implementing a problem-solving task to ensure task effectiveness; 2) Teachers’ roles during the implementation of a problem-solving task are multidimensional; 3) Teachers’ roles after a problem-solving task can help to further enhance student learning; 4) Teachers can create a rich classroom environment that cultivates and encourages a problem-solving culture; and 5) There is a disconnect between the theoretical frameworks in problem-solving research and teachers’ perception of the practical usefulness of such frameworks.
For the intent of this study, the participants were given labels as identifiers to maintain anonymity. Teacher A refers to the first participant who was interviewed and Teacher B refers to the second participant who was interviewed.

4.1 Theme: Planning Before Implementing a Problem-solving Task to Ensure Task Effectiveness

In order to encapsulate a comprehensive picture of teachers’ roles in problem-solving instruction, it is crucial to include what teachers do and what their roles are prior to a problem-solving task. This helps to show their thinking behind the purpose of their lessons. Grouws (1985) states that many aspects of problem-solving instruction are affected by the plans and decisions that teachers make. Therefore, it is crucial to document descriptive data about teachers’ planning and decision-making processes. Oftentimes, problem-solving research is focused on the processes during which problem-solving is taking place, and not before or after it (Grouws, 1985). Both teachers from this study identified two areas with regards to the planning of problem-solving instruction; the first is what to plan and the second is how to plan.

4.1.1 Planning For Engaging Problem-solving Tasks

Types of problems and creating authentic tasks. Problem-solving tasks would not exist if there were no problems for students to solve. Both teachers discussed the importance of choosing rich and meaningful problems for students. This is done during the planning of the problem-solving task. Teacher A discussed the importance of quality over quantity. She said that new teachers tend to get “bogged down” by the quantity of tasks that they have to do. Instead, she asserted that teachers should focus on the quality of the learning task. Students “don’t have to do 80 questions for one thing... one or two really good quality questions are going to suffice.” Furthermore, she addressed that complex, rich problems need to be used to their full potential.
Oftentimes, “a really good rich problem…has multiple skills in it” that can be taught. The problem can be divided into “small little problems”, and teachers can first target the small skills. Then, the teacher can “give [students] the big problem, and they have to connect all of those [small skills] together.” Teacher A also said that these rich problem-solving tasks are often open-ended in nature. Given that Teacher A was primarily a kindergarten teacher, she also discussed the types of problems that students engage in while in kindergarten. Particularly, she said that kindergarteners “don’t really have as many pre-set problems,” because the kindergarten curriculum is so play-based. However, she said if she does use a pre-set problem, it is usually pretty “basic,” “simple,” “fast” and “open-ended”.

Teacher B’s discussion of the types of problems focused around student engagement and the authenticity of the tasks. She said the best way for students to be engaged in a problem-solving task is by giving students “realistic situations and practical problems” – tasks that are about realities that students can relate to and that “matter to them.”

**Making connections to the self and the world.** Both teachers contextualized the idea of planning authentic tasks through the notion of making connections. More specifically, they discussed two distinct types of connections that are necessary for student engagement in the problem-solving task. The first can be labeled as ‘making connections to self”, where the engagement level of the problem is dependent on how the students are able to connect to the problem on a personal level. The second can be labeled as ‘making connections to the world’, where engagement level is dependent on how the problem can help connect students to the world around them.

In terms of ‘making connections to self”, Teacher A discussed the importance to choosing problems that “connect to the math they know,” in order to help students integrate math concepts
in meaningful ways rather than compartmentalizing concepts as discrete entities. Similarly, she went on to say it is important to find problems that give students opportunities to “use those skills again for another problem.” Teacher B talked about helping students to see themselves being reflected in the problems. Teachers can do this by “using kids’ names” in the problems and choosing problems that are “focused on [the students].” This leads to the second idea of ‘making connections to the world’. Teacher B discussed establishing authentic tasks that help students to make connections to the world around them. Oftentimes, the problems provided in textbooks are unrealistic and impractical to students. Teacher B said to rectify this, teachers should “really make it matter to kids” – that is, they should let the problems be as “real” as possible and be “as hands-on as possible.” When kids see there is a problem that is worth solving, they will be more engaged.

These two teachers’ experiences on finding authentic problem-solving tasks add a new perspective to Lester and Kehle (2003)’s Model of Complex Mathematical Activity. They asserted that the ineffectiveness of problem-solving instruction is due to the oversimplification of problem-solving tasks. They also point out that there is a distinguished segregation between the ‘math world’ and the ‘real world’; students tend to problem-solve in the ‘math world’, where they apply abstract mathematical concepts in hypothetical situations. With that in mind, mathematics are learned separately from their practical uses, and often there is no connection between mathematical concepts (Lester & Kehle, 2003). Both teachers in the interview emphasized the importance of creating authentic problem-solving tasks with real world applications. Teachers who are implementing these complex integrations of mathematics with the real world are contributing to new perspectives and more effective instructional methods.
4.1.2 Planning Process

In terms of planning a problem-solving lesson, both teachers were familiar with the 3-part math lesson structure of lesson planning (Van de Walle, 1999). First and foremost, Teacher A reiterated the importance of teachers knowing the curriculum. “Reading[ing] [the] curriculum over and over again… will help [the teacher] to see the connections” between math topics, as well as help them see instances when students come across teachable moments. Understanding the curriculum expectations help teachers to focus their lessons on the big ideas. Teacher A stated that during planning, teachers should have the big ideas and concepts in mind; they need to focus on the basics. For example, Teacher A identified the math fundamentals in the kindergarten curriculum to be the counting principles and the skills involved in knowing how to count to 10. She said teachers should gear their lesson planning towards those big ideas because “it is a little bit difficult to problem-solve if [students] do not have the base foundations of math.” Teacher B explained that when she plans, she first considers “what [unit] we’re supposed to be working on, and then [she] build[s] a problem around [that]”. After the teacher has the big ideas and unit in their mind, they can make “formalized lessons that are geared towards specific math skills [that they] want to cover,” adding on the problem-solving piece afterward. Teacher B mentioned teachers also need to consider the places where problem-solving tasks can be incorporated; they may not necessarily take up the whole lesson. She may start off with a challenging question as a way to engage the students, or use it at the end as consolidation practice. Evidently, there are many things to be considered when planning for a problem-solving task.

Lester (2013) has commented that teacher planning has been neglected as a contributing factor of problem-solving research. The information gathered from the two interviewees contributes to this collective knowledge of teacher planning of problem-solving tasks.
4.2 Theme: Teachers’ Roles during the Implementation of a Problem-solving Task are Multidimensional

The primary objective of problem-solving instruction is the advancement of students’ problem-solving abilities (Lester, 2013). During a problem-solving task, students are faced with many unknown stimuli simultaneously. Competent teachers need to consider a wide variety of factors and make decisions accordingly, to ensure that the student receives the most learning in any particular problem-solving task (Lester, 2013). Both interviewees emphasized that teachers’ roles during a problem-solving lesson are vast. It is not enough to just present the students with the problem; they have to consider other factors as well (Lester, 2013), such as facilitation, grouping, strategies, questioning and differentiation.

4.2.1 Teachers’ Roles as Guides to Navigate Students through the Problem-solving Process

According to Lester and Kehle (2003), some definitions of problem-solving that are used in the literature are not actually conducive to teaching students to problem solve. It was interesting to hear the participants’ definitions of problems solving, given their more practical experiences with teaching in the classroom. Teacher A defined problem-solving as “figuring it out” and “finding a way to come to some sort of resolution for an issue that surfaces.” Both teachers reinforced the idea that the problem-solving process is crucial and should not be overshadowed by the need to find the correct answer. This corresponds with Lester and Kehle’s redefined definition of problem-solving that better encompasses practical concerns, such as coordination of experience, content knowledge, familiar representations, patterns of inference and intuition (Lester & Kehle, 2003).

Both teachers’ discussions of the definition of the problem-solving process include the coordination of experience and content knowledge. They focused less on discussing patterns of
inference, representations and intuition. This gives insight into how classroom teachers understand problem-solving, versus problem-solving conceptions in the literature. For instance, Teacher A presented a teacher’s role in problem-solving instruction as that of a “guide” who “help[ed students] see that [what they are doing] is math”; the teacher was not merely there to give out the answers. According to the participant, as teachers we need to:

Find any way possible to ask [students] questions, to make statements, to rephrase what you’re saying, to clarify vocabulary, whatever it is you need to do that guides [students] and helps them make those steps forward without giving them the answer, without spelling it out.

Teachers are there to help students make sense of the problem and to guide them to figure out the answer themselves. Teacher B also asserted to this. She said it was important to give students the freedom to try their own strategies, even if they were not the most efficient strategies. It was only after they tried the less efficient way that they would come to see how much easier the alternative way could be. Teachers could also “nudge [students] in the right direction” and provide students with the time to figure out the problem as the participants suggested. Similarly, participants addressed the importance to be flexible with time. Teacher B would sometimes “steal time from another subject” if it means giving students the chance to solve the problem in a “better way.”

At the same time, participants identified a fine balance between giving students autonomy to engage in problem-solving and not having students become so stuck on a problem that they lose the motivation to do it. Teacher A said it is a “big challenge to try to get [students] to work through a problem without giving up.” This leads to the next section’s discussion of using questions to scaffold learning.
4.2.2 Teachers’ Roles in Asking Good Questions

One impact of teachers’ roles during classroom problem-solving instruction is the art of questioning. In their interviews, both teachers commented on how much questioning can help to expand students’ thinking and make the problem-solving task that much richer. Teacher A has consulted a number learning resources to help improve her questioning skills in math instruction. She comments that effective questioning takes a lot of thought and practice to perfect. Both teachers used types of questions that were very open-ended and could be used as a scaffolding strategy to help students through the problem-solving process. Teacher A said that oftentimes, there were “a variety of different ways to phrase what you want to say and/or re-phrase what you want to say.” In terms of questioning, teachers should try to “just find the most open way possible to ask [a] question.” Both teachers also said that they use questioning to help students make connections. Teachers “need to be there to make that connection for [the students] and to have them see what that connection is.” Asking questions to help students realize that similar problems can be solved using the same way, or that they can apply the skills they learned in one problem to other problems, can help students to make connections between mathematical concepts. Grouws (1985) contested that while teacher questioning has been studied regularly, it is often applied to math in general. It is therefore helpful to study teacher questioning within the context of problem-solving to give insights into how teachers can ask effective questions during problem-solving tasks (Grouws, 1985). The experiences that the two teachers shared in this study contribute to the understanding of using questioning within a more problem-solving specific context, therefore addressing the concern that Grouws brought up in 1985.

Metacognition. Lester (2013) claims that problem-solving research still knows very little about what teachers need to do to develop students’ metacognitive abilities. While there have
been research studies done to demonstrate ways students can improve their metacognitive abilities (Lester, Garofalo & Kroll, 1989), there is still little understanding of whether these skills can be taught in classrooms, and the specific skills teachers need to teach them in the classroom (Lester, 2013). This research study provides two teachers’ who use questioning as an instruction method to insert metacognitive skill building in the classroom.

One major type of questioning that Teacher A and Teacher B both said they used in their math programs is to stimulate students’ metacognition. It is not enough for students to know how to solve a problem; they have to know how they solved that problem. Many rich questions can be asked to initiate metacognitive discussion during problem-solving tasks. Teacher A’s favourite question has always been, “How do you know that?” She stated that “everything [should be] followed up with ‘How do you know that?’” When students are asked how they know something, they are pushed further into thinking about how they can justify what they know and how they know it. Teacher B brought up similar metacognitive questions, such as “How can you show me?”, “What do you mean by this?”, and asking students to clarify their answers.

4.2.3 Teachers’ Roles in Teaching Problem-solving Strategies

Since there has been a lack of attention drawn to the role that teachers play in real classroom problem-solving tasks (Lester, 2013), it is relevant to consider what these two interviewees had to say about their roles in teaching strategies during problem-solving instruction. In terms of domain-general teaching strategies, teachers were specifically asked about whether they use the 4-step problem-solving model of the Ontario Mathematics Curriculum (2005). Both Teacher A and Teacher B found the four-step problem-solving model to be too structured. When asked what she thought about the 4-step model, Teacher A said:

Yes, I think it’s important. Do I think that I would teach it in as structured, like you have to do this, then you have to do this, and then you have to do this and then you have to do this?
No, I would not say that I do that, but I think that in terms of how you have them function and how you have them approach the questions, definitely hits on those four points, just not in such a very distinct formalized way, if that makes sense.

Teacher B confirmed this. She talked about how many teachers have the “anchor charts” with the problem-solving steps on them, but she “doesn’t think it works for every student.” She stated:

I don’t think everyone thinks the same way. I will refer to the step-by-step how to solve any problem, I will go there sometimes with certain kids, but with other kids it’s not how they learn… It depends on the person; some kids totally plan it out and solve the problem. Some kids spend all their time planning and don’t execute really well, and they need a little help with that, and some kids dive right in and tackle it and they solve it the weirdest way.

Teacher B went on to say she prefers to give kids the freedom to try their own strategies and then hone in on more effective strategies as to how to solve a problem.

The Ontario Mathematics Curriculum prescribes George Polya’s four-step model to give students a domain-general model to use when engaging in problem-solving. There has been little evidence to show the effectiveness of teaching domain-general techniques to students (Sweller, 1990). It was interesting to see that based on the experiences of these two teachers, they did not find the domain-general (apply to all) type of problem-solving strategies to be particularly applicable to their classroom instruction.

4.2.4 Teachers’ Roles in Organizing Independent and Collaborative Learning

Discourse about teaching students twenty-first century skills rarely goes by without discussion surrounding developing students’ problem-solving skills and collaboration skills (Binkley et al., 2012). Teachers play a big role in deciding how they group students in their problem-solving tasks to ensure collaborative learning. The two interviewees discussed their experiences with grouping during problem-solving tasks. Since Teacher A is a kindergarten teacher, she spoke specifically about grouping concerns that arose in kindergarten. She said that
in kindergarten, it depends on the situation. Since many problem-solving opportunities arose during play, they mostly worked in small groups. Independent work was a skill that kindergarteners were learning, and she usually did not do as much whole-group math problem-solving in kindergarten.

Teacher B also tended to use a variety of grouping types from individual to small-group and whole-group tasks. She stated:

I mix it up and I don’t always wait for [students] to be confident. It’s only if they need a group lesson to build confidence to work on their own. I find I’ll actually mix it up. I do all kinds of different things. So sometimes we’ll chip away at something as a big group, a whole class, with me as a leader, and sometimes I give them problems in small groups and I'll start them off like that. Sometimes I'll start them off on their own…but I don’t build up to independence, I actually mix it up.

One of the issues Lester (2013) discussed in his article was the tendency for researchers to focus on the experimental “microanalysis” of individual problem-solving performances. In this study, the two interviewees’ shared their experiences in problem-solving instruction not only at the one-on-one individual level, but also at the small group and whole group level. Teacher A and Teacher B’s accounts directly addressed the issue that Lester raised in 2013 stating that there was a lack of focus on problem-solving instruction happening at the classroom and small-group level (Lester, 2013).

4.2.5 Teachers’ Roles in Differentiating for Diverse Student Needs and Strengths

There are many ways to differentiate for students’ varying abilities in problem-solving tasks (Keislar & Stern, 1970). Both interviewees added to this discussion by incorporating their own unique experiences in addressing differentiation in problem-solving. The two teachers both stated that one challenge in implementing problem-solving was catering to varying student
abilities. When problems were not at a suitable challenge level, student engagement decreased. Both teachers emphasized that differentiating for students was a key component to making a problem-solving task successful. Teacher A noted that oftentimes, students in kindergarten naturally “differentiate[d] themselves.” They had different learning centers to choose from and so “they [were] not going to do something they really [didn’t] understand, and they [were] not going to engage in play they really [didn’t] understand.” Teacher A went on to say:

Kindergarten is a developmentally-based program, which means that each child has to be dealt with individually. Students not only have to learn problem-solving, but at the same time they are also learning about learning skills. Teachers have to differentiate according to students’ problem-solving ability as well as learning skills ability.

Teacher B personally found learning centers to be a useful tool for differentiation. She would normally place students into same ability groups, where “each group will have their own customized problem to solve.” She said that some ways to differentiate problems would be to change the numbers, change the wording, and change the number of steps needed to solve the problem. She said differentiating this way was quick and easy, and “it’s an extra two or three minutes of work.” Using centers also maximized the teacher’s one-on-one time with students who needed it. She would often send kids off to centers, and work with kids in one particular center. An example she gave was:

So one table will have a question and you try and figure out the answer. One table [where] you can see everyone else’s answers. One table will be manipulatives and you work it out that way…and one [table] will be come see me and I’ll work through something with you.

These ways of differentiating were all important contributors to the teacher’s roles during problem-solving instruction.
4.3 Theme: Teachers’ Roles after a Problem-solving Task Can Help to Further Enhance Student Learning

Both teachers agreed that learning does not end after a problem-solving task is complete. A big component of mathematical learning comes after the completion of a task. These teachers discussed some of the routine activities they did after a problem-solving task, the ways they communicated to students, the ways students communicated their solutions, and how they as teachers assessed the problem-solving tasks.

4.3.1 Post Problem-solving Activities

Participants found that a number of activities could be used as follow-up to help students consolidate their understanding of the problem-solving task. One major theme that both teachers raised was the importance of repetition of skills and problem-solving tasks. Students did not learn a skill by just coming across it once; they had to familiarize the skill through repeated exposure. Teacher A said that repetition in kindergarten was very important. As teachers,

You have to make sure that you provide [students] with another opportunity in which to practice that skill in some way or discover that skill again, so they that they can then make the connection to those two things and they can continue to practice and repeat that [skill] in a variety of ways. Sometimes you are going to have to manufacture that experience versus waiting for them to create that experience.

Teacher B added that she often repeated a similar problem later on, even after they have completed the unit. That way, she saw “if they’ve really, really learned it, or just remembered the steps because the steps were up on the board.” Another form of repetition was application. Teacher A emphasized the importance of getting students to apply the skill they learned in different ways, scenarios and problems.
4.3.2 Communication as a Way to Enhance Problem-solving Tasks

One key task that teachers did immediately after a problem-solving task was communicate. There were many forms of communication discussed by the two teachers. For them, communication was a way to make students’ thinking explicit, which helped the teacher to know how the student got to the solution of a problem, and in turn possibly identify where they made faulty reasoning errors. Both teachers affirmed the importance of communication. Teacher A said that the “communication piece is really key to problem-solving… and that’s how we provide the foundation and the bases for when [students] get to the [higher] grades.” Focusing on communication skills helps students “see that what [they’re] thinking in [their] head[s] can actually be expressed verbally.’ She went on to say that, oftentimes, when students were asked how they knew the answer, they answered with comments like ‘Well, I think it’, or ‘Well, my head just said’. It was up to the teacher to teach students how to explain their thinking and make it a habit of explaining their thinking.

Both participants emphasized that teachers need to make communication accessible in the classroom. Teacher A discussed some of the difficulties for kindergarteners when it came to engaging in communication. Students not only lacked the basic math knowledge to communicate using proper vocabulary, they also lacked the “base knowledge of language”. She found it important, therefore, to provide students with different means to express themselves – to give students opportunities to discuss their math thinking orally, in written form and using charts. She also highlighted that teachers need to model what good communication looks like. In order to do this, Teacher A said that teachers need to “practice listening to [students] and [practice] responding to them.” When students first start, as teachers, “you sort of have to be their voice, and you’ve got to model what’s going on in your head, model what is sounds like. ‘In my head,
my brain said....’’ Teacher A affirms that think-alouds are a great way for students to see how teachers can communicate their thoughts.

The two interviewees both said it was important for students to have many opportunities to practice communication; teachers needed to encourage student talk. Teacher A said that students should “constantly do it, and orally talk about it all the time, and they [would] become very proficient in being able to explain their answers.” She said that since students in kindergarten mostly used oral talk to explain their thinking, they really benefit from having one-on-one conferences with a teacher. Teacher B said conferring with a student about the problem “works beautifully” and “it’s [like] a dance.” She also encouraged students to communicate with each other in a congress. At the end of a problem-solving task, students could congress to share the effective ways to solve the problem. Teacher B said it was easier to get students to share their own solutions because “they love to explain their reasoning and why they’re right, but don’t like listening to other people explain.” Both teachers touched briefly on the topic of communication and the importance of it, but did not go into detail to explain what goes on during student talk interactions.

Lester (2013) emphasized the lack of descriptive information on the various types of communication that happens in the classroom. In particular, he said teacher-student interactions and student-student interactions require more study. This research study found that both teachers focused on discussing what their interactions with students sounded like and the questions that yielded from it. Interestingly, they did not discuss student-student interactions during problem-solving tasks. There may be various reasons for this. To speculate, it could be that teachers are busy helping students during tasks, and therefore they do not hear as much student-student interactions. More student-student interaction descriptions may give us further insights.
4.3.3 Assessing Problem-solving Tasks

Both participants agree that assessing student learning is necessary for teachers to be informed on student progress. Both teachers discussed a variety of ways that they assess students in problem-solving tasks. In kindergarten, grades are not given, so Teacher A said a lot of is based on “observation” and “it’s not quantifiable”. She used a variety of observational techniques. She “[took] a lot of pictures” of student work. She and the early childhood educator (ECE) worked together, so while Teacher A taught, the ECE made recording observations. It was important to her to “watch what the children are doing, [and write] down …some of the comments that they are saying and we will dissect those later.” She does this because she knows that observations must be done constantly because students are constantly changing and improving. Oftentimes “you write it down; well, two weeks later it’s different.” She also kept an “online digital portfolio for all the children, so all the pictures will go into their portfolio.”

Teacher B said she “[gave] them a really broad range” of assessments. She used “math tests” for individual assessment, “how do you do in group work” for group assessment, and “talking about your problem-solving”. She also gave students tasks where a problem is solved incorrectly and it is up to the student to identify why it was wrong and how it can be fixed. From these two teacher experiences, it appears that problem-solving tasks can be assessed in a vast number of ways, some formal and some informal. These insights help to contribute to assessment strategies in problem-solving literature, which Silver (1985) mentions deserves much attention.

4.4 Theme: Teachers Can Create a Rich Classroom Environment that Cultivates and Encourages a Problem-solving Culture

A teacher’s role in problem-solving instruction is one major contributor to students’ problem-solving learning in the classroom (Alswaie, 2003). Another major contributor is the
atmosphere of the classroom (Silver 1985). The two interviewees identified several aspects that could contribute to a productive problem-solving classroom culture. Teacher A really emphasized building community in the classroom. Problem-solving often involve taking risks and trying new strategies. A community is a place where students feel safe and accepted. She said, “Children are not really going to learn…if they don’t feel comfortable.” To build community, Teacher A stated:

I think it’s really important, regardless of the grade you’re teaching, to take that month of September to create that community…Take your time. I know our curriculum is full and there is a lot in there, but you will save yourself a lot of time later on down the road if, in September, you do a lot of community-building things in your classroom. You talk about what your expectations are in the classroom. You start that problem-solving right away in the classroom. Easy problem-solving, but problem-solving nevertheless. [This] opens itself to conversations and allows the children to see not only that you value what they have to say, but that everyone else is going to value what they have to say and not going to judge each other on what they say. They are going to be co-learners in the whole experience…If [this] is your focus for September, not really the math that comes out of it, but the process…by the time you get into the end of October, beginning of November, you can do an awful lot of really great problem-solving. You have that sense of community, you have those independent learners and you have those learners that are willing to share and to talk and express what they are doing, then you can really start looking at the math.

She went on to discuss how the way teachers treat mistakes can influence the feel of the classroom culture. She stated, “You have to be ready for them to make mistakes, and then you have to be ready to use that as a means for them to learn further.” Additionally, Teacher A discussed teachers’ specific roles in creating a classroom culture that is conducive to problem-solving. Teachers needed to “open [themselves] to learning with [the students].” Teachers needed to foster independence and teach students the process of learning before implementing
content. Teachers needed to be self-questioning and reflective. Teacher A added that sometimes, “You have to be brutally honest with yourself.” When a problem-solving task doesn’t work, “it might be the [the teacher’s] problem.” The task may be “too difficult”, or the students are “not quite developmentally ready.” Teachers also need to be “constantly researching” better instructional practices and trying new teaching techniques.

Teacher B focused on student engagement and materials used in a classroom. She said it was important to design a classroom that was “open” and “accessible” for the students: display the manipulatives out in the open for students to access whenever they wanted; make sure “[students] know they are allowed to use [the manipulatives].” Teacher B said it was important to “spend the money [and] put the stuff out there.” Students “need[ed] big baskets of everything,” such as “blocks,” “play dough,” “marker caps” and “every manipulative you can think of.” Students should be provided with “every possible fun way to write down [their] work.” Students “don’t want to draw in pencils or their books, they want markers and chart paper,” so teachers should give them the markers and chart paper. Furthermore, Teacher B stated that from her experience, engaging primary grade students was a lot easier than engaging junior grade students; there were always a few students in the junior grades who were not engaged in the problem-solving task. Teacher B said the only thing that worked with those students was the teacher’s “one-on-one attention,” so it was important to “try and gear things, and get the room set up, centers going, [in order] to maximize the amount of time [the teacher could] spend with that group of 5 or 6 kids [who] refuse… unless [there’s] one-on-one [attention] with [the teacher].”

Stake & Easley (1978) suggested that it was useful to document aspects of classroom ecology that contributed to a problem-solving culture. Both teachers contributed to this and suggested many methods they use to make their classroom atmosphere rich for problem-solving.
They discussed the importance of building community, valuing mistakes, and providing useful manipulatives. This affirms what Stephan & Whitenack (2003) found in regards to classroom factors that contributes to exploring, sharing ideas, collaboration and risk taking.

4.5 Theme: There is a Disconnect between the Theoretical Frameworks in Problem-solving Research and Teachers’ Perception of the Practical Usefulness of Such Frameworks.

Meta-analysis literature reviews have noted a disconnect between theoretical research on the study of problem-solving and the practical experiences of problem-solving that happens in real classrooms (Santos-Trigo, 2007). It is important to consider both the theoretical and practical understandings of problem-solving and examine how they contribute to each other. This research study focused on examining teachers’ understanding and perception of some of the theoretical models as applied their everyday classroom instruction, which are described below.

4.5.1 Teachers’ Perception of the Role Problem-solving Plays in Math Education

Both teachers thought problem-solving was a crucial component of problem solving. Teacher A said “it [was] huge” in mathematics, and that it was “very difficult to make connections between [the] pieces of knowledge without the ability to problem-solving.” She said that given its important role, she implemented problem-solving “every day.” Similarly, Teacher B said problem-solving was the most important aspect of learning math. She said problem-solving could have many contributions to math education. For example, it could act as an “ice-breaker” to get kids hooked; it could be used as a way to challenge more advanced students and “keep [them] on their toes”; and teachers could used it to “base [their math] program around.”

4.5.2 Teaching Math through Problem-solving

Teaching math through problem-solving directly competed against the 1980s push for teaching the basics (Schoenfeld, 2007). In today’s schools, these two distinctions still exist. Both
teachers discussed their experiences with teaching math through problem-solving. Teacher A focused on problem-solving in the kindergarten program. She said, “The beauty of the full-day kindergarten program is that it’s inquiry-based and it’s based in play,” so “the majority of their learning… is basically problem-solving. It’s in everything they are doing.” She asserted that the kindergarten program was essentially problem-based, where “a lot of [the] teaching occurs in play, and sometimes that play is not pre-planned…[and there] isn’t really pre-set problems.” Teacher A said this kind of learning, structured around problems, helped students to “discover” and “explore.” It cultivated students’ independence by “giving them the opportunity to run the classes.” She said math should not be taught unit-based, but rather problem-based. She also added that there were some basic math skills that would be “difficult” to teach through problem-solving, such as the conventions of long division. Teacher B also said that she based her program around problem-solving, and that problem-solving was infused into her math program.

There have been an abundance of research studies conducted to examine the affects of teaching mathematics through problem-solving (Lester & Charles, 2003). While the two interviewees only mentioned problem-based learning briefly, several conclusions can be drawn. First, the kindergarten play-based program fits well with the current research on teaching mathematics through problem-solving. Students discover problems in play, and must solve and learn math concepts in the process. Second, some concepts may be difficult to teach using a problem-based framework; some conventions of math have to be taught directly. Thirdly, while both teachers discussed teaching mathematics through problem-solving in a positive light, they did not give enough details to show they could fully implement it in a complete math program. This once again confirms the gap between theory and practice.
4.5.3 Teachers’ Knowledge of Theoretical Problem-solving Frameworks and Their Usefulness in Classroom Teaching

One of the theoretical frameworks was already discussed in a previous section. It is in regards to whether teachers use domain-general, 4 step models to teach problem-solving. Both teachers said they did not follow the 4-step model closely, but did refer to it on occasion. In addition to that theoretical framework, teachers discussed their general knowledge of problem-solving research. Teacher A discussed the research she has done in topics of problem-solving. She said that research of problem-solving in the early grades, including problem-solving in play-based programs, have been scarce. She has researched a number of resources on the “developmental understanding of math” in kindergarten programs and how “young children…conceptualize math.” She has read books written by Marian Small and Doug Clements on “how to ask questions,” “how to engage students,” and “how [teachers] see the math.” She said that “understanding how [students] learn math and how their brains develops math [will help teachers] to better understand how it fits in inquiry-based programs.” In regards to theoretical frameworks as a whole, she stated:

I’m never one to say it needs to be just this one theory or this other theory. I often find that really when you are practicing and you are putting in a strong program, the reality of the situation in the classroom is you often take in bits and pieces of theories and you put them together.

Teacher B said books on problem-solving research are not her preferred resource to help her improve her problem-solving program. She said she has many texts in her class for teaching teachers, but she has not touched them since teacher’s college. She said, “I’ll flip through [them], and it’s useless and not helpful and not real-life practical.” Teacher B found that the best resource was talking to teachers with experience.
The issues the teachers brought up confirms a disconnect between theoretical research and its practical uses. Neither of the teachers found the four-step model theoretical framework to be particularly useful. Even when Teacher A did do research, it is focused on practical implementation strategies. Teacher B disregarded theory-based books because they were impractical to her classroom instruction. This demonstrates that researchers need to examine how to infuse theory to be more useful in practical classroom settings (Santos-Trigo, 2007).

4.6 Conclusion

In Lester (2013)’s literature review, he identified four areas that were often ignored in problem-solving research, these being:

1) Relatively little attention to the role of the teacher in instruction;
2) Too little concern for what happens in real classrooms;
3) A focus on individuals rather than small groups or whole classes; and
4) The largely atheoretical nature of problem-solving research.

Even though this qualitative research study is just a drop in a large ocean of research studies in the area of problem-solving, it does address the gaps in the literature that Lester (2013) mentions.

Throughout this chapter, I discussed many areas of concern that two experienced elementary teachers addressed in their interviews. The five themes covered a wide variety of issues, focusing in particular on teachers’ roles and classroom culture.

The first theme addressed the behind-the-scenes work that teachers do to ensure successful implementation of problem-solving in their classrooms. Teachers addressed the importance of planning for engaging problem-solving tasks. Different types of problems yielded different types of learning from students. Creating authentic tasks helped engage students. It also helped students to make connections to themselves and the world around them. Teachers went through
an extensive planning process that often involved consulting the curriculum and designing problems based on big mathematical concepts.

The second theme focused on the actions that happened during problem-solving instruction. Teachers acted as guides to navigate students through the learning process. Asking thoughtful questions to students could make students think more deeply about the problem and help them to become metacognitive problem-solvers. Teachers also needed to consider how to teach problem-solving strategies during the lesson. The debate ended with the discussion of collaboration versus independent learning in problem-solving tasks, and differentiating for students’ needs and strengths.

The third theme followed up with what teachers did after a problem-solving session. There are a number of activities that teachers can do to further enhance learning after a task. Getting students to communicate their understandings was crucial for consolidation of learning. Assessment of problem-solving tasks was addressed as well.

The fourth theme depicted a variety of factors that helped to create a rich problem-solving culture in the classroom. Teachers discussed the importance of building community, valuing mistakes, providing materials and student engagement. The final theme also addressed teachers’ perceptions and uses of current theoretical frameworks in problem-solving research.

These findings helped provide me with a more comprehensive understanding of problem-solving in the literature and in the classroom, particularly the roles that teachers played in all aspects of the problem-solving process from beginning to end. Listening to teachers talk passionately about their experiences with teaching problem-solving created new insights that were often not seen in the literature. Many of the issues discussed in this chapter will contribute to the following chapter’s discussion about the significance of the research findings.
Chapter 5: Implications

5.0 Introduction to the Chapter

This final chapter will commence by re-examining the main purpose of this study established in chapter 1. It will then detail the research findings and discuss their significance. In order to do so, this chapter is divided into five sections. First, it will discuss and give an overview of the key findings analyzed in Chapter 4. Second, it will discuss the implications of the research findings. Both broad implications for the educational community and narrow implications for my own teaching practice will be discussed. Third, it will discuss some recommendations for future practice. Fourth, it will prospect future areas of research that have been raised by the results of this study and finally, it will accompaniment a brief conclusion to this research study.

5.1 Overview of Key Findings and their Significance

There are relationships between the results of the present study and the abundance of studies found in the literature throughout the years in the topic of mathematics problem-solving in elementary school. Through the interviews with both of the teacher participants, several major themes appeared that were relevant to the study of problem-solving in the elementary grades. These include: 1) Teachers’ planning before Implementing a problem-solving task to ensure task effectiveness; 2) Teachers’ roles during the implementation of a problem-solving task are multidimensional; 3) Teachers’ roles after a problem-solving task can help to further enhance student learning; 4) Teachers can create a rich classroom environment that cultivates and encourages a problem-solving culture; and 5) There is a disconnect between the theoretical frameworks in problem-solving research and teachers’ perception of the practical usefulness of such frameworks.
The first theme, teachers’ planning before implementing problem-solving tasks, helps to ensure task effectiveness, reinforce the importance of planning and preparation. Lester (2013) states that teacher planning impacts the teaching of problem-solving in many ways. It is also not a distinct category, but rather flows into other areas in various ways (Lester, 2013). Interviewees asserted a number of important factors that contributes to planning successful problem-solving tasks. These include, teachers should consider the types of problems they are going to present to the students. Additionally, it’s important to create authentic problem tasks that can address multiple skills and are open-ended in nature. Interviewees defined authentic tasks as ones that allow students to make connections to themselves and to the world around them. Furthermore, a good planning process requires teachers to understand the curriculum expectations in order to think about how to incorporate the big ideas into the problem-solving tasks.

The second theme discussed the multidimensionality of teachers’ roles during problem-solving tasks. It insinuated that teachers were guides and facilitators who helped students to navigate through the problem-solving process. Lester (2013) has proposed that teacher behaviours during the problem-solving task could influence how the students received the problem. Various teacher behaviours include: asking clear questions or giving hints, understanding and explaining the math correctly and verbal and non-verbal communications by the teacher (Lester 2013). This study added onto Lester’s ideas in saying that teachers must ask meaningful and thought-provoking questions during the task. Teachers must also encourage independent thinking and collaborative learning, and differentiate for diverse student needs.

The third theme focused on what happens after a problem-solving task. Both teachers agreed that there are still many learning opportunities after students have completed their problem-solving task. Teachers can encourage students to consolidate their learning through
discussion of how they got to their answer, and how they knew that it was the answer. Teachers sometimes need to teach problem-solving strategies explicitly. Lesh and Zawojewski (2007) have stated that some strategies are too general to be useful for students. The interviewees agreed with this in that they thought that sometimes, strategy steps were too rigid for student thinking. Teachers could also use assessment to inform student progress and help provide feedback of their process. This could often be informal conferencing in primary grades.

The fourth theme suggested that teachers could create a rich classroom environment to help students cultivate problem-solving skills. Teacher A affirmed that it is important to create a sense of community in the classroom, where students feel safe and accepted. Students should know that the mistakes they make are apart of learning and they should not be afraid to make mistakes. Teacher B emphasized that making manipulatives accessible and ensuring students had the materials they needed to solve the problem-solving tasks was important as well.

The final theme explores the disconnection between theoretical frameworks in problem-solving research and the practicality of such frameworks as applied in the classroom. While both teachers interviewed in the present study did use components of theoretical frameworks in their practice, such as teaching problem-solving strategies and teaching mathematics through problem-solving, they did not feel the need to focus on any one particular framework. Furthermore, they stated that they picked and chose from different theories and strategies to fit the needs of their programs and students.

5.2 Implications

5.2.1 Broad: The Educational Research Community

The present study contributed to the progression of the educational research community by integrating experienced teachers’ perspectives in problem-solving research. From a broad
perspective, this study has the potential to inform policymakers and curriculum planners in several ways. It indicated the following: 1) teacher’s roles in problem solving in math in the elementary grades is crucial to student learning; 2) providing useful resources for teachers and students helps the effectiveness of problem-solving; and 3) classroom teachers may not find theoretical frameworks developed in the literature to be practical or useful resources for their teaching. Policymakers and educational researchers can consider these issues for future educational reform.

5.2.2 Narrow: My Professional Identity and Practice

From a personal perspective, this study has three implications for me as a teacher. First, teaching rich problem-solving involves careful planning. Teachers need to take into consideration the problems that engage students, as well as students’ interests when picking problems; they need to find problems that have an appropriate amount of challenge. Second, a teacher’s role during problem-solving involves asking questions that further enhance student thinking. Teachers should focus on the process of problem-solving. They need to see how students are arriving at the solutions. Also, problem-solving is not an overly structured activity where students lose opportunities to explore different solutions to various problems. It is also not so unstructured that students lose track of where they are going and get frustrated in the process. Teachers need to decide how much freedom and guidance to give to students during the tasks. Third, teachers can further extend the student learning by having students to engage in reflection. Thinking about how to get students to express the ideas of how they solved a problem is useful for their ability to communicate mathematical ideas and to use their metacognitive skills to think about the solutions they have made. All of the knowledge that I have gained from interviewing
these teachers and finding the major themes they discussed, helped me to develop my own practice in becoming a better problem-solving facilitator.

5.3 Recommendations

The implications of this study helps to formulate several practical recommendations for ministries of education, school administrators and teachers. I have developed some practical advice for the educational community to ponder. The main points of my recommendations are:

- For the Ontario Ministry of Education: Consider introducing problem-solving courses into teacher education programs. Much thinking-focused pedagogy is being discussed in current teaching programs, such as inquiry-based learning and critical thinking. It would further enhance the learning of teacher candidates if a course was specifically focused on discussing the importance of these thinking pedagogies and how to effectively plan, implement and reflect on them in the classroom.

- For school boards and administrators: It is important to provide teachers with rich resources and materials for implementing problem-solving in the classroom. From the discussion with teachers in this study, both mentioned the importance of being able to access practical resources for problem-solving. Oftentimes, rich, engaging problem-solving tasks require more preparation and hands-on materials than other types of math lessons. Providing teachers with easily accessible materials for problem-solving tasks can encourage teachers to implement them more into the classroom.

- For teachers in the classrooms: There are many strategies teachers can implement to enhance their problem-solving instruction. Before any problem-solving task, teachers should ensure that they choose problems that are authentic in nature and are engaging for the students. They should have a thorough understanding of the curriculum expectations,
so they can address them throughout the problem-solving task. During the task, teachers should give students enough time to grapple with the problem. Teachers need to practice asking good questions and ensure that the questions they ask help students to develop metacognitive understandings of how they are solving the problem. Teachers should teach explicit problem-solving strategies at their discretion, depending on student needs. They also need to encourage and provide collaborative problem-solving opportunities. After the task, teachers need to give students an outlet to reflect, communicate and share their understanding of the problem. It is also important to create a rich classroom environment that promotes problem-solving culture. Manipulatives should always be accessible for students to use.

5.4 Areas for Further Research

Given that this research study consisted of two individual teacher interviews, it is obvious that the results yielded cater only to the experiences of these teachers. The purpose of this study is not to generalize results to all teachers. Instead, this study aimed to examine the experiences of the teachers interviewed in the hopes of being able to share their personal experiences with respect to teaching problem-solving. Teachers are researchers in many ways. They study the goings-on of their classrooms, and reflect and inquire about how they can improve their teaching. Giving teachers a unique opportunity to voice their expertise will help to add fresh perspectives to the educational research community.

That being said, this study yielded questions and ideas for future areas of research. Several questions emerged, including: 1) During planning, how can teachers find ways to incorporate concepts from different math units into a problem-solving task, thereby integrating multi-strand math concepts? 2) During implementation, how can teachers incorporate
collaborative problem-solving tasks whereby students solve problems together, but still ensure individual accountability? 3) How can teachers incorporate technology into improving problem-solving experiences? 4) How can math problem-solving be incorporated with other subject areas such as language, science and the arts? 5) What teaching style and teacher characteristics best encourage students’ problem-solving motivation? It would also be interesting to examine the disconnection between the theoretical frameworks and teaching practices of problem-solving. Why does such a disconnection exist? What process does it take for research-based findings in the educational research to reach the hands of teachers in classrooms? Why is it so difficult for teachers to access such research findings? Also, the up-and-coming topic of teaching mathematics through problem-solving merits further exploration. Given the time constraint of the interviews, the teachers did not go into detail about how they have taught math topics through problem-solving. It would be interesting to interview teachers who do teach using this method, and examine its effects compared to teaching the more traditional way.

5.5 Concluding Comments

To conclude, the purpose of this study was to examine the roles that teachers play in implementing problem-solving into their math programs. Several relevant themes arose from the findings of the interviews. These themes show that teachers have great propensity to impact student learning through the implementation of problem-solving tasks. Before the task, teachers should ensure that they pose engaging and authentic problems that are relatable to the students. During the task, teachers can use questions to guide students, demonstrate metacognitive skills, teach problem-solving strategies, and allow for individual and collaborative learning opportunities. After the task, teachers need to give students the opportunity to reflect and communicate the process it took for them to reach their solutions. It is also crucial for teachers to
build a classroom environment that promotes problem-solving by advocating for students to take risks, as well as valuing mistakes as opportunities for learning. Theoretical frameworks were also examined for their ability to influence teachers’ problem-solving instruction.

Granted, ‘problem-solving’ is amongst a plethora of popular buzzwords floating in the departments of education across Canada today. As educational reform progresses, some of these buzzwords might stay, some might be long forgotten, and some might transform into new buzzwords that are synonymous in its meaning. For now, the only thing for certain, as addressed at the beginning of chapter 1, is the fact that there is a shortage of students who are graduating with degrees in the STEM fields from Canadian universities (Mishagina, 2012). If Canada wants to be a part of the competition to become a leader in the fast growing knowledge-based global economy, then teachers, school board administrators, and ministries of education must consider the skills students need to learn in order for them to contribute to Canada’s future accomplishments. So let us not just examine the word ‘problem-solving’ because it is a trendy buzzword, but actually understand the purpose behind it.
References:


Appendix A: Letter of Consent for Interviews

Date: Dec 1, 2015

Dear ____________,

My Name is Sophia Yuan and I am a student in the Master of Teaching program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on documenting teachers’ experiences in teaching problem-solving. In particular, I will examine the role that teachers play in implementing problem-solving activities in their math programs. I am interested in interviewing teachers who have been involved in teaching problem-solving in elementary school mathematics. I think that your knowledge and experience will provide insights into this topic.

Your participation in this research will involve one 45-60 minute interview, which will be transcribed and audio-recorded. I would be grateful if you would allow me to interview you at a place and time convenient for you, outside of school time. The contents of this interview will be used for my research project, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a research conference or publication. You will be assigned a pseudonym to maintain your anonymity and I will not use your name or any other content that might identify you in my written work, oral presentations, or publications. This information will remain confidential. This data will be stored on my password-protected computer and the only people who will have access to the research data will be my course instructor Ken McNeilly. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate. You may also choose to decline to answer any specific question. I will destroy the audio recording after the paper has been presented and/or published, which may take up to a maximum of five years after the data has been collected. There are no known risks or benefits to participation, and I will share with you a copy of the transcript to ensure accuracy.

Please sign this consent form, if you agree to be interviewed. The second copy is for your records. I am very grateful for your participation.

Sincerely,
Sophia Yuan

416-436-2979
sophia.yuan@mail.utoronto.ca

Course Instructor’s Name: Ken McNeilly
Contact Info: kenneth.mcneilly@utoronto.ca
Consent Form
I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw from this research study at any time without penalty.
I have read the letter provided to me by Sophia Yuan and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ________________________________________________

Name: (printed) ____________________________________________

Date: _____________________________________________________
Appendix B: Interview Questions

Thank you for taking the time to sit down and do this interview with me. Just to reiterate, this interview is being conducted as a qualitative study for the Master of Teaching program at OISE. This interview is audio-recorded, however your identity will be kept confidential. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate.

The overall research question that I will be addressing through my research is to examine what strategies elementary teachers use and what role they play in implementing problem-solving in their math programs.

Section A: Background Questions

1. What is your name?
2. What is your personal education background?
3. How long have you been teaching?
4. How long have you been teaching elementary grade mathematics?

Section B: Teacher Practices

1. How frequently do you incorporate problem-solving (PS) in your math program?
   a. (Reword) How much time do you delegate your math teaching time to problem-solving?
2. Before the PS activity: How do you plan for a PS activity? What are some things you consider when preparing a problem-solving lesson?
   a. How do teachers select meaningful and engaging problems to use during a problem-solving activity?
   b. How do you decide whether to have students work individually, groups or as a whole class?
   c. How can teachers differentiate for students of varying abilities in a PS activity?
3. During the PS activity: What happens during a PS activity? How do you manage the students?
   a. How do you teach problem-solving strategies to your students? What are some problem-solving strategies that you’ve taught that worked particularly well for your students?
   b. What kinds of questions do you ask?
   c. How do you judge between when students need assistance and when they should keep thinking about the problem on their own?
4. After the PS activity: What are some things that can be done after students complete the activity that will help to enhance their learning?
   a. How can teachers help make students’ thinking process explicit in a problem-solving activity?
      i. What are some ways you’ve used to get students to show, justify and represent their solutions?
   b. How can teachers encourage students to discuss and reflect on the solutions and the strategies/process they used in a PS activity?
c. How can teachers assess students’ use of strategies and understanding of a problem-solving activity?

5. How can teachers create a classroom culture that helps to promote problem-solving behaviours in students?
   a. How can teachers motivate students to engage in problem-solving?

6. Describe a particular instance when you taught problem-solving. Discuss the successes and challenges you had and what insights you drew from it. (Optional)

Section C: Beliefs and Values
1. In your opinion, what does problem-solving in mathematics entail?
2. Are you aware of any theoretical approaches toward teaching PS?
   a. Do you find the theory useful in your teaching of PS? How have they influenced the ways you teach problem-solving? What are the benefits/drawbacks you have seen when applying these theories to your classroom practice?
3. What do you think about The Four-Step Problem-solving Model posed in The Ontario Curriculum document (understanding the problem, making a plan, carrying out the plan, reflecting on the solution)? Have you used it? Do you find it useful? What are its benefits and drawbacks?

Section D: Influencing Factors
1. What are some challenges that teachers face when facilitating problem-solving in elementary grade math programs?
2. Do you have any advice for new teachers who wish to incorporate more problem-solving in their math programs?

Section E: What Next
1. What resources exist to help teachers who want to implement more problem-solving in their math programs?
2. Do you have any goals to improve your future practice in teaching problem-solving?