ONE TEACHER’S FOCUS ON READING IN A GRADE 9 MATHEMATICS CLASSROOM:
A CASE STUDY

by

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ABSTRACT

This thesis reports on a qualitative study that documented one teacher’s research-based practice of teaching students to read in a Grade 9 ESL Academic mathematics course. Specifically, this thesis focuses on the description of the range of strategies and reading-based activities that the teacher used; the experiences and influences that led him to include reading strategies in his regular instructional practice; and, the challenges that he faced when integrating these strategies routinely as part of his daily mathematics program. The complexity of simultaneously teaching mathematics and reading strategies in the context of a Grade 9 ESL Academic course is also discussed.

The study was conducted early in the second semester of the 2007-2008 school year. A variety of data collection methods were used: interview, classroom observation, and document collection. The findings of the study provide concrete examples of designing lessons that embed the use of reading strategies (e.g., vocabulary development, reading supplementary text, and reflection) to teach or inform mathematics concepts. The large number of ESL students in the observed class underscored the importance of incorporating reading strategies into the mathematics program in order to facilitate ESL students’ language learning processes. The teacher under study focused on using additional literature as an aid to develop students’ deeper understanding of mathematics concepts and introduced reading strategies as a means to improve students’ reading comprehension of supplementary text; however, he did not apply these strategies to lessons directed at the comprehension of specific mathematics text. The conclusions suggest that mathematics teachers require substantive classroom-based evidence and support from Ministry of Education personnel, subject specialists, school administrators, and peers in order to be convinced of the value of reading in mathematics class and to embark on their own program for implementing reading strategies and reading-based activities into regular mathematics learning activities.
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В тилу куваилась перемога…

ukrainian saying

I would like to express my gratitude to all those who gave me the possibilities to complete this study and without whom my thesis could not have been written…

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CHAPTER ONE: INTRODUCTION

Rationale

Since the earliest days of public education, schools have been charged with the responsibility of preparing their students for the demands of daily life. In today’s information-rich world, educational institutions have an increasingly important role in developing literacy skills that empower students to comprehend and interpret the information that bombards them from print and visual media as well as the World Wide Web. They must acquire lifelong reading skills to live productive and independent adult lives:

Adolescents entering the adult world in the 21st century will read and write more than at any other time in human history. They will need advanced levels of literacy to perform their jobs, run their households, act as citizens, and conduct their personal lives. They will need literacy to cope with the flood of information they will find everywhere they turn. They will need literacy to feed their imaginations so they can create a world of the future. (Moore, Bean, Birdyshaw, & Rycik, 1999, p. 99)

These literacy advocates and researchers offer seven principles to support adolescents’ literacy growth, based on the premise that “adolescents deserve expert teachers who model and provide explicit instruction in reading comprehension and study strategies across the curriculum” (p. 104). For the past two decades, researchers and educators have been emphasizing that all teachers, regardless of content specialization or grade, are responsible for developing and extending students’ literacy skills, contending that reading and writing are best taught within the context of discipline-based courses, not within the confines of English or language arts programs (Lapp, Flood, & Farnan, 2008, p. viii).

After completing high school, not all students will become geographers, historians, scientists, or mathematicians but every graduate will require important literacy skills: writing, listening, speaking, and reading in order to understand basic information they encounter including
maps, tables, graphs or formulae. There is no doubt that individual content areas have their own vocabulary and conventions (i.e., language) which shape their unique literacy requirements and determine the instructional approaches that are most appropriate and applicable.

The importance of developing literacy skills via and within subject curricula has been acknowledged and debated in articles in numerous mathematics education journals, professional mathematics publications, and Ministry of Education (MOE) policy documents. For example, in Ontario, the importance of teaching students to read, write, speak, and listen mathematically is underscored because communication is stated as an explicit process strand and achievement category in the provincial curriculum policy documents for mathematics from Kindergarten to Grade 12 (Ontario Ministry of Education, 2005, 2007). In the internationally influential *Principles and Standards for School Mathematics* (2000), it is emphasized that literacy development has a particularly strong role to play in the teaching and learning of mathematics i.e., “students who have opportunities, encouragement, and support for speaking, writing, and reading, and listening in mathematics classes reap dual benefits: they communicate to learn mathematics, and they learn to communicate mathematically” (National Council of Teachers of Mathematics [NCTM], 2000, p. 60). In this thesis, I have chosen to focus on one aspect of literacy development in the mathematics classroom, specifically, developing reading literacy.

“Reading literacy involves understanding, using and reflecting on written information for a variety of purposes” (Organization for Economic Co-operation and Development, 2003, p. 108). Developing reading literacy is defined in this thesis as the process of helping students to acquire reading strategies that they can employ to comprehend, interpret, understand, apply, and reflect upon written information for multiple purposes. Mathematics, like all other subject disciplines, has its own language which influences developing reading literacy, i.e., “in reading mathematics text one must decode and comprehend not only words, but also signs and symbols, which involve different skills” (Barton & Heidema, 2002, p. 15). This means that when studying mathematics,
students should be made aware of reading strategies that facilitate the process of reading particular mathematics notations (e.g., symbols, graphs, numerical and algebraic expressions) that may be embedded in the mathematics text passages. At the same time, Borasi and Siegel (2000) strongly recommend giving students the opportunity not only to read specific mathematics text but also provide them access to a diverse range of texts and genres that require mathematical reading.

Given the curriculum focus on and research attention paid to including reading in the regular mathematics classroom, it can be argued that all teachers are teachers of reading and that mathematics teachers are no exception. However, most mathematics teachers still do not view teaching students how to read mathematics text, or providing instruction about reading skills, strategies, and processes within the regular mathematics program to be within their purview or expertise: “mathematics and science teachers often say that they feel the least prepared to teach students how to read” (Barton, Heidema, & Jordan, 2002, p. 24). Even elementary school mathematics educators who are “generalists and have been trained in reading instruction…do not see literacy [in the context of mathematics] as part of their skill set…. Most reading teachers do not teach the skills necessary to successfully read in mathematics class” (Kenny, Hancewicz, Heuer, Metsisto, & Tuttle, 2005, p. 10).

Researchers argue that mathematics teachers should develop pedagogical literacy skills, in general, and pedagogical reading skills in particular, in order to instruct students in the appropriate strategies and positively impact their development of reading literacy. The recent series of books *Literacy in the Content Areas* [e.g., Cook (1986), Irvin (1998), and Lapp and Flood (2008)] together with the Ontario Ministry of Education documents [e.g., *Think Literacy Success: Grades 7-12: The report of expert panel on students at risk in Ontario* (2003); *Think Literacy: Mathematics subject specific examples Grades 7-9* (2004)] have provided Ontario’s mathematics teachers with a number of strategies as well as classroom-ready resources and
materials. However, little is known about the degree to which mathematics teachers value the inclusion of reading instruction within the regular mathematics program; what challenges teachers face in their efforts to teach reading; what practices mathematics teachers use to develop reading literacy in their mathematics classrooms; and what supports and resources mathematics teachers rely upon to teach both mathematics and reading in mathematics. The proposed study seeks to describe one mathematics teacher who is an early adopter of the principles and practices of teaching students to read and comprehend text in general and mathematics text in particular.

Context of the Study

The topic of reading literacy in the mathematics classroom has been my research interest since I first encountered it during my experiences as a teacher and graduate student in the Ukraine, between 2003 and 2005. My first scholarly studies were with and about Ukrainian educators and researchers who had developed a focus on literacy across the curriculum. When I began graduate studies in Canada, I quickly noted a fortuitous coincidence: literacy skills featured prominently in the North American educational literature. My experience, as a teacher and graduate student in the Ukraine, where reading and writing (fundamental literacy skills) fall under the umbrella of general learning skills (a component of all courses) provided rich opportunities to learn about and study ways to help students to read mathematics text.

In my role as a teacher and tutor of mathematics, my interest in the topic of reading instruction became further piqued when I noticed that my own students seemed to struggle when challenged to read their textbook or other text-based materials that contained domain-specific vocabulary, representations, and conventions. For example, my experience taught me that students were trying to memorize definitions instead of understanding their meaning, and that they had problems with finding and applying appropriate theorems or descriptions in order to solve mathematics problems or understand the explanation of a solution.
In my own classroom, I tried to implement a number of reading strategies based on theories attributed to Ukrainian educators, psychologists, and pedagogues. I developed several lessons that included research-based strategies and skills that were recommended as being ones that students should apply in order to comprehend text. At the time, I was using the textbook *Algebra and introduction to the calculus: A textbook for Grade 10 secondary school* by Mukola Shkil, Zinaida Slepkan, and Olena Dybinchyk (2002) and focusing on strategies to improve reading skills such as dividing the text into separate units; posing probing questions to encourage students to think about the structure of theorems; constructing explanations and definitions; and, actively and collaboratively solving mathematics problems (Chernik & Voytsekhovska, 2005).

When I came to Canada, I soon discovered that the issue of reading in the mathematics context was also a topic of concern in that many North American researchers had also reported that a number of students have difficulty reading and comprehending mathematics text (Carter & Dean, 2006; Kajander & Lovric, 2005; Lager, 2006; Österholm, 2006). Kajander and Lovric posit that the main reason for this might be that students have not been explicitly taught how to read mathematics text:

>a new feature of the present reform in high schools in Ontario is that the students are not taught how to use a textbook; i.e., they do not have a chance to develop experience in reading mathematics text and thinking about it. (p. 156)

Carter and Dean suggest that mathematics teachers do not consistently teach the strategies familiar to reading specialists that help students to develop the skills that could facilitate their reading of mathematics text.

In May 2007, I attended the annual conference of the Ontario Association for Mathematics Education (OAME). There I participated in a workshop by a mathematics teacher who shared his experience of integrating reading strategies based on research principles in his mathematics classroom. I saw that it was possible to enact the theories that I was interested in and I believed that it could be instructive and supportive for other mathematics teachers to learn more
about the strategies and practices undertaken by this teacher leader—this became the impetus for
the study. I also recognized that this teacher’s experience and practice was in many ways unique;
thus the need for an extreme case study became evident.

Purpose of the Study

Since the teacher is the main arbiter of any classroom activity, the responsibility for
teaching reading in a mathematics context falls squarely on his or her shoulders. Given the
important role of the teacher’s orchestration of classroom activities, the purpose of this qualitative
study is to document one unique teacher’s research-based approach to communication in the
secondary mathematics classroom, specifically in the area of teaching students to read text by
using a variety of strategies, contexts, and activities. Through classroom observation, in-depth
individual interviews, and analysis of teaching materials developed by the teacher under study,
this research seeks to describe in detail:

(a) the range of strategies that one experienced teacher uses to teach students to read text
in the mathematics classroom;

(b) the variety of materials that this teacher generates and uses in regular classroom
activities while teaching students to read text; and,

(c) the experiences and influences that led this teacher to learn about, design and include
research-based literacy strategies for teaching students how to read text in a variety of
mathematics lessons as part of his regular instructional practice.

The teacher who was selected as the focus for this study is atypical because of the
intentional and innovative steps he took to translate theory into practice. There have been many
reform innovations initiated and supported in Ontario targeted towards mathematics education by
both MOE and powerful subject associations such as the OAME and the Ontario Mathematics
Coordinators Association (OMCA). Their foci have included graphing calculators, dynamic
geometry software, and at-risk students; however, no province-wide initiatives directed to
mathematics teachers have sought to advance the communication aspects: listening, reading, writing, speaking, and reading.

The teacher under investigation is an innovator in that he determined his own professional goals for integrating the context of his mathematics courses; moreover, he has initiated a formal self-study program about reading strategies and reading-based activities by seeking out, acting upon and evaluating the effectiveness of strategies and recommendations from the relevant empirical literature to support his own classroom practice. Given this individual teacher’s commitment to the issues around developing reading literacy in the mathematics context and his determined, proactive efforts to research empirically-supported strategies; develop resources based on his interpretation of the research; employ these resources in regular classroom situations; and, most importantly, share both his resources and the outcomes of the experiences in translating theory into practice, he exemplifies the notion of the rich, illuminative case.

Overview of the Thesis

This thesis contains of six chapters, each of which begins with an introduction that outlines what is included in that particular chapter. Chapter 2 presents the theoretical framework of the study which informed the analysis and interpretation of the data and a literature review that critically examines research about pertinent aspects of reading instruction in general and instruction in reading mathematics text in particular. Chapter 3 provides both a methodological framework as well as details about the methods of data collection and data analysis. Chapter 4 is dedicated to the presentation of the data. Chapter 5 offers a discussion of the main themes that emerged from the study: the role of the context, challenges to implementing reading instruction in the mathematics classroom, and research-informed practice. Chapter 6 includes the findings and implications of this study both for professional development and for educational research.
CHAPTER TWO: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Introduction

In this chapter, I present the theoretical framework that guided the analysis, interpretation and discussion of my data. The foundations of this research are found in an established body of theoretical work. First, since this study is related to issues of communication in the mathematics classroom, a consideration of how communication is understood as an integral mathematics curriculum process expectation guided the research; however, I include only one of the four facets encompassed by the umbrella term ‘communication’ (i.e., reading, writing, speaking, and listening): reading mathematics text. Secondly, I use constructivist theories as a framework to guide the study, specifically focusing on key tenets from Vygotsky’s theory of the Zone Proximal Development (ZPD), scaffolding, and reciprocal teaching.

The literature review is a presentation of empirical studies that examine strategies or describe instructional techniques shown to be effective in helping students to read and comprehend text. Firstly, I present a brief description of both putative claims for the benefits of explicit reading instruction and empirically-supported instructional reading strategies in general. The main emphasis of the latter part of the literature review is on the presentation of recent studies that have explored the effectiveness of strategies, teachers’ instruction, and students’ difficulties with reading text in a mathematics context. Included in this section is a description of issues central to reading mathematics text illustrated and illuminated by selected studies that relate to reading specific mathematics text and others that focus on the effect of helping students to comprehend text in the mathematics context either by using reading strategies or different genres of text (e.g., fiction, non-fiction, children’s literature, teen novels, poetry, and mathematics textbooks).
Theoretical Framework

Focusing on Communication in the Mathematics Classroom

Communication in the mathematics classroom is distinct from communication in other subject areas, because, as is the case in many other disciplines, mathematics as a field has its own specific language and conventions (Morgan, 1999; Pimm, 1987).

There is oral communication (speaking and listening) and written communication (reading and writing). Much the same might be said of teaching and learning in many others subject areas; however, there are special features of mathematics classrooms and mathematical language that make communication a particularly significant issue [for both mathematics education researchers and mathematics teachers]. (Morgan, 1999, p. 129)

To learn mathematics, students need to be taught and learn how to use and understand mathematics language through listening, writing, speaking, and reading (Morgan, 1999; Pimm, 1987; Pugalee, 2005, 2007).

Encouraging students to define their ideas, explain their reasoning, and describe their strategies by reading, writing or speaking contributes to the development of their mathematics language (Morgan, 1999; Pimm, 1987). Explicit support for the importance of communication in the mathematics classroom figures prominently in both the 1989 and 2000 NTCM Standards¹, and in Ontario’s policy documents that define the intended mathematics curriculum. These documents highlight communication as one of the seven broad process standards, and contend that all mathematics students must be taught and must learn how to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical

thinking and strategies of themselves and others; and use the language of mathematics to express mathematical ideas precisely (NTCM, 2000, p. 60).

It is assumed that accurate and clear communication of mathematical language can help students to understand instruction provided by the teacher and make available to students a replicable model for thinking, speaking, and writing about mathematical concepts to many audiences including peers and teachers. Self-talk, using appropriate mathematical language, is believed to be an effective way for students to analyze and evaluate their own mathematical thinking and understanding. Kilpatrick, Hoyles, and Skovsmose (2005) stress that the learning and teaching process in the mathematics classroom involves communication with both “human and non-human agents” (p. 130), e.g., teachers, peers, written text, and computer software. It is because of this classroom reality that they argue that students should learn to construct meaning from these different presentations of information because each conveys mathematical knowledge.

Researchers posit that there are four modes of communication: writing, listening, speaking, and reading (Morgan, 1999; NTCM, 2000; Pimm, 1987; Pugalee, 2005, 2007). Each of these modes plays an important part in building students’ understanding and learning. Pugalee (2005) points out that speaking, listening, writing, and reading “play an important role in shaping students’ learning experiences” (p. 49) in the mathematics classroom. There are some who argue that these components are tied together and cannot be separated: “the meanings that are developed from the texts should become part of the interactive relationship among reading, writing, listening, and speaking” (Pugalee, 2005, p. 53).

While I believe that all four dimensions of mathematical communication are important and interrelated, for the purposes of this study, I have chosen to focus only on reading activities and reading instruction in the mathematics classroom because the topic is understudied and often misunderstood by mathematics educators, particularly at the secondary school level. In order to understand the depth and breadth of what is meant by the phrase ‘reading in the mathematics
classroom,’ I begin by addressing the specific mathematics language and reading skills that researchers contend students should have in order to comprehend mathematics text.

Reading in the context of mathematics is “broadened by the fact that printed text engages students in reading words with integrated numerals, symbols, and diagrams” (Adams & Lowery, 2007, p. 162). Researchers from various fields have identified and classified specific reading skills that students should obtain and use in order to successfully comprehend mathematics text and its specific, written mathematics language. O’Halloran (2000) stresses that the multisemiotic nature of mathematics language (including symbolic and grammatical systems) makes it difficult to understand. According to O’Halloran, multisemiotic (e.g., visual, symbolic, language) systems influence students’ understanding and contribute to the meaning of text. Schleppegrell (2007) bases his ideas on the notion of a mathematics cognitive register that incorporates multiple recognition systems: a multiple semiotic system (e.g., mathematics symbolic notation, oral language, written language, graphic and visual displays); and grammatical patterns (e.g., technical vocabulary, dense noun phrases, being and having verbs, conjunctions with technical meanings, and implicit logical relationships).

Adams and Lowery (2007), Morgan (1999), and Schleppegrell (2007) point to the importance of conjunctions (e.g., less, more, for, and, if, all, any, and or) in reading mathematics text. These conjunctions play a significant role in understanding the context and comprehending the meaning intended by mathematics explanations, definitions, and problems. This means that precise mathematics language requires specific reading skills for comprehending the meaning of mathematics text.

Carter and Dean (2006) identify three specific reading skills as steps in comprehending mathematics text: (a) decoding (which means students are able to translate written words and symbols to speech); (b) knowing vocabulary (which means students understand mathematics terminology and the meaning of words in the particular context); and, (c) comprehending (which
means students activate their prior knowledge and make connections to knowledge stored in their memory). They contend that these skills are not isolated from each other and must be used “fluidly to help the reader construct meaning from the text” (p. 133).

Kirkpatrick and Makar (1980) suggest that there are two sets of reading skills, i.e., general (which students apply while reading text in any content area) and specific (which students need when reading mathematics text). They suggest that the following skills should be developed in mathematics content: adjusting vocabulary to include words specific to mathematics and words with unique meanings in mathematics; reading the vocabulary of mathematics symbols and variables; reading mathematics text carefully and slowly; reading charts, graphs, and tables; understanding word problems; and responding to the unique characteristics of mathematics reading materials (e.g., textbooks, journals).

Various researchers (Adams & Lowery, 2007, Carter & Dean, 2006; Kirkpatrick & Makar, 1980; O’Halloran, 2000; Schleppegrell, 2007) proffer their own unique classifications and delineations of reading skills essential for reading mathematics text. Different perspectives occur because the researchers have explored the issue from dissimilar theoretical perspectives; nonetheless, the fundamental concepts that are described by each classification system are essentially identical. Furthermore, they embed the same reading skills. Kirkpatrick and Makar’s definition of specific mathematics reading skills describes skills that are unique to mathematics language and the importance of these skills is recognized by various researchers. It is because of their detailed explanation and clear application for practice that I have elected to use their definition of reading skills in this study.

The responsibility for teaching students how to interact with written text and how to read and comprehend mathematical communication falls squarely on teachers’ shoulders. It is the content and process of instruction for developing reading skills and processes in the mathematics class that will support or be a barrier to learning and understanding (Alrø & Skovsmose, 2002).
The following section presents one such approach to teaching reading processes through active learning.

_Constructivist Approach in Learning and its Implementation in the Classroom_

Recently, researchers and practitioners alike have emphasized the integration of a constructivist approach into the mathematics classroom’s teaching and learning processes. Constructivist theory focuses on the ways in which students generate their own understanding: building knowledge from their personal experience in a particular learning situation. Noddings (1990) indicates that constructivism as a theory of learning includes both a cognitive position and a methodological perspective. The methodological perspective emerges from the theoretical foundation via methods of teaching that reflect the fundamental tenets of the theory, e.g., creating situations in which the learner and the teacher work together to solve problems, engage in inquiry, and construct knowledge; and, in which the learner is an active participant in constructing his or her own knowledge based on the learning situation and teachers’ guidance. In this study, I focus on constructivism as a methodological perspective since I am interested in the teachers’ role in students’ learning.

Constructivism is making a strong entry into educational thinking in general and mathematics education in particular. Draper (2002) defines the role of the constructivist teacher as one of assisting students by creating “an environment that will provide the learner with the opportunity to construct knowledge” (p. 522), and will allow “the learner to wade through experience…[providing] opportunities for the learner to question, probe, and ponder” (p. 522). Although the word constructivism is not explicitly stated in any Ontario mathematics curriculum document, the implicit language of the documents is compatible with a constructivist view. For example, in Ontario, the provincial curriculum policy document explicitly states that students “should explore concepts individually and cooperatively; independently and with teacher
direction; through hands-on activities; and through the study of examples followed by practice” (Ontario Ministry of Education, 2005, p. 23).

Constructivist perspectives are grounded in several theories, one of which is Vygotsky’s theory of the ZPD (1986). Vygotsky describes ZPD as the gap between what a given child can achieve alone; the potential level of development that can be achieved independently; and that which the child can achieve with an adult’s guidance or in collaboration with more capable peers. Although Vygotsky developed the theory of ZPD, he did not suggest specific strategies to guide practitioners to facilitate students’ development, or identified strategies that promote effective guidance and collaboration during learning and teaching. The following authors proffer several approaches that make Vygotsky’s theory concrete, including ‘scaffolding’ (Wood, Bruner, & Ross, 1976) and ‘reciprocal teaching’ (Palincsar & Brown, 1984).

Wood, Bruner, and Ross (1976) investigated how a tutor could help students to solve problems. They used the term ‘scaffolding’ to refer to the gradual guidance and support for learning and problem solving which a tutor provides. In this study, the authors explored the ways in which a tutor gave a student instruction in response to the child’s success or failure in order to help the child to move to the next level of instruction. The researchers worked with three, four, and five year old children to construct a pyramid from blocks. The results suggested that children of different ages demanded different degrees of support and different kinds of instruction. Regardless of age, however, the researchers found that tutors needed to scaffold all children by engaging them in the task; establishing and maintaining an orientation towards task goals; highlighting critical features of the task that might be overlooked by the child; helping to control frustration; and, demonstrating how to achieve goals.

Palincsar and Brown (1984) developed the theoretical notion of ‘reciprocal teaching’ through their study of reading activities. They described reciprocal teaching as occurring when the “teacher and students took [take] turns leading a dialogue concerning sections of a text” (p.
In reciprocal teaching, the focus is on teaching students specific strategies which they can apply to the reading of new text, and this instruction takes place primarily in the context of a dialogue between the teacher and the student, and between peers and the student.

Palincsar and Brown (1984) designed a study in which they measured students’ achievement in reading and comprehension by using standardized reading comprehension tests and by describing the progress of a cohort of students who participated in a reciprocal teaching situation as members of a treatment group. The researchers formed four groups, two of which received instruction and two control groups that did not. In the control groups, students were required to read text and answer questions without any intervention. In the treatment groups, students received instruction that embodied a reciprocal teaching process, i.e., summarizing, questioning, clarifying, and predicting. Each of these strategies was supported by active collaboration and dialogue between teacher and students.

The results showed that the treatment groups outperformed the control groups and students’ improvement was not only in dialogue but also in comprehension. In addition, the researchers noted significant changes within treatment groups, e.g., student summaries included not only paraphrasing of the text but also the main idea, and students were able to formulate questions while self-controlling the process of understanding text. Researchers stressed that the role of the teacher in reciprocal teaching was crucial, since during dialogue teachers were responsible for taking into account students’ level in order to respond with appropriative supports and challenges to guide the students’ problem solutions.

Cook (1986) also supports the idea of a constructivist approach and the importance of the teacher’s role in developing students’ reading processes. He characterizes reading comprehension as an active process that helps students to bring their experience to the text, involves them in active thinking, engages them in discussion, and helps them become strategic readers. Three
distinct factors impact the reading process: the reader–background experience, motivation, prior knowledge, and reading strategies; the text–content, language, and organization; and the context of the reading situation–purpose, task, environment, and teacher’s interactions during the reading process.

Cook (1986) stresses that although the learner must be an active participant in building understanding and making sense while reading text, teachers have a responsibility to provide students with specific skills and processes that turn them into strategic readers. According to Cook, a strategic reader employs a variety of effective comprehension activities: predicting, connecting with prior knowledge, determining importance, self-questioning, creating graphic organizers, using context to figure out new vocabulary, and applying appropriate strategies for each reading situation.

Summary of the Theoretical Framework

The proposed study was informed by theories that describe a constructivist approach to teaching practice as well as the unique challenges of implementing communication in the mathematics classroom, specifically, reading in the mathematics classroom. Vygotsky’s theory, reciprocal teaching, and scaffolding represent foundations for strategies that may help students to move along the developmental continuum and support them in their efforts to learn reading strategies in the mathematics classroom by taking into account their individual level of knowledge, experience, skill, interest, and also the context of the learning. By focusing only on specific reading skills, teachers may be supported to make their first foray into teaching reading for mathematics learning. Furthermore, the theoretical framework guided the design of the study and analysis of the data.

Literature Review

This section reviews studies related to strategies and instruction for helping students to comprehend different types of text. The first section presents a brief description of reading
strategies in general. The main emphasis of the second part of this literature review is on recent studies that have explored the effectiveness of particular strategies, teachers’ instruction, and students’ difficulties with reading text while studying mathematics. Included in this section is a description of some of the issues central to reading mathematics text, illustrated by selected studies related to reading specific mathematics text and others that focus on explicating students’ reading strategies as evidenced by teaching mathematics through different genres.

*Instruction for Reading and Comprehending Text in any Content Area*

Dole, Duffy, Roehler and Pearson (1991), in their literature review, synthesized the findings of 14 years of research that was focused on reading comprehension and its teaching. Through their meta-analysis of 20 significant and oft-cited studies, these researchers sought to construct a shared understanding of what is meant by the word ‘comprehension’ and to describe instructional strategies that had been shown to be effective in helping students to read text. They examined comprehension instruction from a cognitive perspective, i.e., a view which “assumes an active reader who constructs meaning through the integration of existing and new knowledge and the flexible use of strategies to foster, monitor, regulate, and maintain comprehension” (p. 242). This stance limited the studies they reviewed to those that assumed an active approach to the development of teaching, instructional support, and strategies. Dole et al. developed a recommended set of instructional strategies based on their review and analysis of papers from 1976 to 1990: determining important and unimportant information; summarizing information; drawing inferences; generating questions; and monitoring comprehension.

Determining importance requires that one uses prior knowledge (e.g., knowledge of author’s intentions and goals, knowledge about the structure of the text) to access and evaluate the content of the text and to differentiate important from unimportant information. Summarizing information refers to the process of sifting through large units of text, differentiating important from unimportant ideas, and then synthesizing those ideas to create a new, coherent text. Drawing
an inference is achieved by using visual and kinesthetic reminders to integrate prior knowledge
and text knowledge. Students create their own questions during and after reading text. In addition,
they monitor their comprehension and apply fix-up strategies. In other words, they are said to be
“recognizing and identifying difficult parts of passages taken from commonly used expository
materials” (p. 243).

The summative conclusions of the literature review suggest that all of these strategies
improve students’ comprehension; however, the cognitive point of view on the reading process is
particularly important, i.e., it is more important to introduce students to general strategies that
they can use during reading and comprehending text than to train them in task-specific skills.

Roeschl-Heils, Schneider, and van Kraayenoord (2003) designed a quantitative study in
which they explored how metacognition and motivation influence reading and comprehension
among Grade 7-8 students. The results of this study show that there is correlation between all of
these variables: metacognition had a huge influence on students’ comprehension and on
differences in students’ metacognitive strategies. There were related to the researches’
classification of ‘good’ and ‘poor’ readers. Students’ application of metacognitive strategies
resulted in improved performance. Another finding of this study is that motivation plays an
important part in the reading and comprehension process; if students are interested in reading they
are more involved in reading the passage, a factor that positively impacts their attitude toward
reading.

Kintsch (1986) claimed that two models of text representation are included in the process
of comprehension. The text-based model describes coherence relationships among propositions in
the text and their organization. The situational model describes the connection between students’
prior knowledge and new information in the text.

In order to distinguish between the representational models and their impact on reading
comprehension, Kintsch (1986) designed two experimental studies. In the first, he explored the
contribution of each type of representation to solving word problems. Grade 4 students were asked to solve arithmetic word problems that were classified as ‘easy’ or ‘hard’. The recall protocols of children who read the text of the problems without solving the problem reflected the structure of the text-based model since these students could not use the information contained within the text to solve the problem. In contrast, children who were able to solve the problem were able to do so by creating a situational model. “If a word problem involves a situation or action that students are familiar with, they find it easier to form an appropriate problem model” (p. 92).

In the second study, the author examined two types of text: ‘more’ and ‘less’ coherent. The author posed questions to the participants which showed whether or not students could create a mental map of a town. The results showed that students who read the more coherent version used the text-based model: “The greater coherence of one of the texts yielded a better text-base but had no effect on the situational model” (Kintsch, 1986, p. 101). In addition, the results showed that students recalled the more coherent version of the text much more easily than the less coherent version.

This research implies that teachers should use different instructional approaches to help students to construct meaning by using different mental representations of text. If a teacher wants the student to use a text-based representation, then she or he should introduce students to the features of the text or changes in text organization. If a teacher wants to develop a situational model, then she or he should activate students’ prior knowledge before reading. The text-based and situational models influence both reading and comprehension, and each has its own contribution to students’ understanding and recall of text; however, Kintsch (1986) stresses that for the active reading process, the situational model is more important.

The importance of prior knowledge and its influence on the reading process was investigated by Anderson and Pearson (1984) in their schema-theory. Schema-theory is a
cognitive model that attempts to explain how knowledge is stored in memory. A schema is defined as an abstract knowledge structure that stores data in memory and plays an important role in the interpretation and memorization of new information. In their study, researchers asked participants to read text which included ship terminology and then participants should describe the ship christening schema. According to the results of this study, researchers explained that participants who were familiar with ship terminology were better able to connect and fit new information to old, because they had some expectation of what the text was about. These expectations helped them to invoke their personal memory schema about the topic and to connect pre-existing constructs to new information in text on the topic of ship christening.

Brown (2003) designed a quantitative study that examined how text characteristics and task conditions influenced students’ abilities to find the main idea of the text. The researcher pointed out that readers could use navigation tools in the text (e.g., headings, subheadings, title organization, graphics, paragraphing fonts, boldface, and italic text) as clues to locate information in the text and generate an answer to a posed task. Brown stated that students used skimming and scanning strategies by using navigation tools in order to find the answers. For this study, Brown developed two types of text which included different navigational tools and tasks which were included in these two types of text. The participants of this study were students ($n=500$) between seven and eight years old from New Zealand. In order to make sure that students used navigation tools while locating information within the text, the researcher asked students to find details in a range of passages in a speed-controlled condition (i.e., answer 16 questions in 10 minutes) and identified those who could skim or scan to locate information.

One of the findings of this study showed a strong correlation ($n=131$, $r=0.79$) between students’ ability to locate information and general reading comprehension (which was measured by a standardized paper-and-pencil test: The Progressive Achievement Test). Referring to this result, Brown (2003) recommended: “improving students’ skills in locating information within
prose text through a focus on organizational structure of texts, practice at creating search terms for implicitly stated tasks, locating material through inference...may increase general reading comprehension.”

To summarize, this section of the literature review discussed strategies that facilitate reading and comprehension of text. By focusing on these studies, my intent was to locate the general or well-known strategies that may be employed by teachers when teaching reading of any type of text. I assumed that some of these strategies might be utilized by the participant of my study: a teacher who proactively sought to integrate reading in the mathematics classroom.

*Instruction for Reading in the Mathematics Classroom*

The following studies focus on one strategy that some mathematics teachers use, i.e., the practice of introducing complementary and/or supplementary literature as a vehicle through which students may be introduced to specific reading strategies. Particularly relevant to this study is that this research illuminates the ways in which the integration of ancillary literature may help students to understand mathematics concepts.

Borasi, Siegel, Fronzi, and Smith (1998) designed a qualitative research study to explore how reading mathematics-related text was a catalyst for students’ further communication in the mathematics classroom. They considered that reading mathematics concepts via fictional text in context encouraged students to think more about mathematical ideas and to go beyond the task. The authors stressed that activities generated from such text allowed “students to use that text as a springboard for sense-making and discussion of important mathematical ideas and issues about the nature of mathematics” (1998, p. 275).

Before conducting their research, Borasi and her colleagues developed an intervention project that included a semester-long seminar for the participating teachers. The researchers provided not only professional learning opportunities about the reading strategies but also facilitated curriculum writing sessions in which the teachers created a package of several
mathematics units which focused on the integration of mathematics-related literature (e.g., essays on history and philosophy of mathematics, mathematics stories, and newspaper articles using mathematics).

The research team specified three methods to frame the curriculum writing tasks for the mathematics teachers: say something—an activity in which readers communicate with peers and teachers after reading the passage; cloning an author—an activity in which students write their ideas on cards or create a concept map or other visual arrangement of their ideas; and sketch-to-stretch—an activity in which readers try to transform the idea of the text by drawing their interpretation of the text. These strategies were used to facilitate students’ comprehension of mathematics-related text and encourage students to participate in follow-up discussions about the mathematics concepts presented in a particular passage. After the professional development program, researchers observed lessons delivered by five mathematics teachers. Ultimately, the researchers chose five rich episodes to examine the ways in which these strategies appeared to help students to understand mathematics-related text and mathematics concepts.

The results of this study indicate that one of the principal reasons that teachers should simultaneously teach reading strategies as well as use mathematics-related literature is that this dual approach provides students with interesting information about mathematics as a part of human culture and involves students in both reading and communication. Additionally, such literature appears to motivate students to read and learn mathematics. When mathematics is seen by students as more than ‘boring’ numbers and ‘alien’ theorems, they are encouraged to read deeply and to discuss not only the literary passage but also the mathematics concepts that are central to the text.

Another important finding of this study is the three reading strategies that mathematics teachers used while leading activities based on reading mathematics-related text. The description of data shows that these strategies helped students to understand the text more deeply by
presenting the meaning of the text in different ways: writing, speaking, and drawing. Although in this study mathematics teachers applied these strategies to mathematics-related literature, the researchers posit that these strategies may also be applicable to technical mathematics text.

Adams and Lowery (2007) investigated how reading children’s books with embodied mathematics may help students to understand the passages within a mathematics textbook. These researchers designed a qualitative study involving two Grade 4 participants as subjects. First, the students read a children’s book about organizing a birthday party. The text of the birthday party required students to apply their knowledge of fractions and measurement. Next, the students were faced with the task of reading text from a mathematics textbook with mathematics problems that had similar tasks; however, in this case, the tasks were presented in more formal mathematics language. Adams and Lowery noticed that in both contexts, each student was able to solve the mathematics problems; however, in the two situations they did not use the same mathematics language and or formal mathematics terminology to explain their solutions.

Studies by Adams and Lowery (2007) and Borasi et al. (1998) explored the same instructional strategy, i.e., using mathematics-related children’s literature to improve students’ comprehension of both mathematics text and mathematics concepts. This strategy appears to provide students with additional materials that encourage them to read mathematics text of a different genre and to discuss narrative passages (that may include mathematics vocabulary, concepts, symbols and conventions) with peers and teachers.

Carter and Dean (2006) reported on strategies that mathematics teachers presented to students to enable them to read mathematics text. They investigated the methods teachers used in the process of reading text and the reading skills to which teachers paid attention. The authors studied the ways in which eight mathematics teachers with a range of teaching experience worked with students from Grade 5 to 12. Carter and Dean sought to understand how teachers develop three types of mathematics reading skills in their students: decoding words and symbols,
understanding vocabulary, and comprehending the entire problem. They collected data by recording lessons during which teachers worked on these skills with their students. After that, the researchers classified lessons according to mathematics reading skills in order to analyze how teachers developed these skills and what strategies they used to facilitate students’ comprehension.

The results of this qualitative study showed that most teachers had a restricted knowledge of strategies and skills in reading mathematics text. For example, some teachers paid more attention to vocabulary by explaining 'double-meaning' words and definitions, while others used reading aloud, brainstorming or graphic organizers as strategies for helping students to extract meaning from text. Carter and Dean’s (2006) study indicates that mathematics teachers do not always take into account students’ attitude and their prior knowledge; explain the specifics of mathematics text and reading skills; or use reading activities which make students more independent and strategic readers of mathematics text.

Carter and Dean (2006) conducted their study at the university level in a context in which eight mathematics teachers worked with eight students. This study does not provide opportunities for the reader to see the interaction among all students in the classroom, nor does it reflect the reality of planning daily activities to meet stringent provincial curriculum and large-scale assessment requirements or textbook conventions. In contrast, my research aims to describe the everyday processes that one deeply committed teacher regularly uses to teach a class of students to read text in the mathematics context.

Ostler (1997) conducted an action research study in his mathematics classroom about his efforts to help students to read their mathematics textbook. Ostler found that in his teaching practice, he used the assigned mathematics textbook as a source for practicing problems rather than a source of reading for understanding. In addition, Ostler noticed that students often were not able to make meaning or see connections among topics through presentations of information in
their textbook. He hypothesized that students were reading the textbook in the same way as they were reading a fictional piece, and were unaware of the fact that the mathematics textbook embeds mathematics notations and language that they were expected to know how to read in order to comprehend the text successfully.

After this observation, Ostler (1997) designed an experiment in which he taught students in one high school algebra class four strategies for reading their textbook: (a) identify and understand vocabulary as the words pertained to the problem being worked on; (b) read numerical problems from the ‘inside out’ rather than ‘left to right’, (c) refer to the graph or chart throughout the problem solving; and (d) sometimes read the final solution first before reading the steps of this solution. In this study, the researcher had a small number of participants: a control group with 16 students and a treatment group with 21 students. The data collected were comprised of homework problems assigned over a four week period that were collected and then analyzed for completeness and accuracy. In the treatment group he introduced students to specific reading strategies and assigned homework from the textbook that matched what was taught in the classroom. In the control group, he organized lessons in traditional ways.

The results did not indicate a significant difference in problem accuracy between the experimental and control group. However, there was a significant increase in the homework completed for the experimental group as compared to the baseline data (4 weeks of homework collected prior to the 4-week treatment period). In conclusion, Ostler (1997) states “teaching reading strategies for mathematics may improve students’ ability to successfully complete process-oriented textbook problems” (p. 40).

Ostler (1997) focused his attention on reading mathematics notation (e.g., vocabulary, graphs, numerical expressions, and mathematics problems) from the mathematics textbook. In addition, his reading strategies mainly related to strategies which facilitate reading and
comprehending mathematics problems and their solutions. However, he did not include additional materials for reading outside the textbook.

Reading mathematics text is different from reading text in any other content area. Lager (2006) and Österholm (2006), through separate studies, illuminated the complexity of reading mathematics text because of its symbols, unfamiliar and technical vocabulary and its tradition of combining visual with language components. For example, Lager was trying to identify types of reading challenges that Grades 5 and 6 Spanish-speaking English Language Learners² (ELL) face while reading written algebra items about a linear pattern. This researcher chose ELL because they struggle simultaneously with two languages: English and mathematics.

Lager (2006) suggests that this could be the reason that ELL students have among the lowest academic achievement scores in mathematics. He examined 456 middle-school students, 221 of whom were ELL. First, he gave all students a test that included algebra problems. The resulting scores showed that non-ELL outperformed the ELL group. Next, the researcher selected 24 ELL because their work exemplified patterns of misunderstanding. He showed these students their original work and used interviews to elicit information that could lead to a deeper understanding of their problem-solving strategies. These in-depth interviews helped Lager to categorize the main challenges that ELL faced when reading mathematics text: new technical vocabulary; complex strings of words or phrases which go together; variables; and visual and linguistic forms.

² In Lager’s study and in the recent MOE documents [e.g., English Language Learners/ESL and ELD Programs and Services: Policies and Procedures for Ontario Elementary and Secondary Schools, Kindergarten to Grade 12 (2007a) and The Ontario Curriculum, Grades 9–12: English as a Second Language and English Literacy Development (2007b)], the authors call students whose English is not a first language as English Language Learners (ELL) instead of English as a Second Language (ESL) students.
Another study presents evidence that reading mathematics text is more difficult than reading historical text. Österholm (2006) examined differences among the comprehension process for historical text, mathematics text with symbols, and mathematics text without symbols. The main purpose of this study was to understand whether or not comprehension is affected by the ways in which the content is presented. For example, there were two types of mathematics text which had the same content; however, one was presented with symbols and one without. A total of 95 senior secondary and university students participated in this study. They were required to read three text selections and immediately after complete a comprehension test. The researcher created two types of test, each of which had six questions related to the main idea of the text. Since the mathematics text with symbols and without symbols had the same content, the tests for the two types of mathematics text had the same questions.

The results demonstrated that there is no difference between comprehending historical and mathematical text without symbols; however, there is a difference between reading historical text and mathematical text with symbols, and mathematics text with and without symbols. The researcher stressed that “there is no common type of reading comprehension for mathematical texts in general, but one seems to need several types of skills for different types of mathematics texts with symbols” (Österholm, p. 340). The researcher concludes that there is no difference between reading mathematics text without symbols and historical text which means that, for mathematics text without symbols, students may apply reading strategies learned in other subject disciplines.

Lager (2006) provides clear evidence that while there are some challenges involved with reading mathematics for ELL, mathematics text which includes symbols is also a stumbling-block for native English speaking students. Österholm (2006) extends this notion through the findings of his research which suggest that mathematics text with symbols is more difficult to comprehend in comparison to mathematics text without symbols. Neither Lager’s nor Österholm’s study
suggested instructional strategies for how to improve students’ comprehension of text in general and mathematical text in particular. Their findings support the idea that mathematics text is difficult to comprehend and “there is a need for more explicit teaching of reading comprehension for texts including symbols” (Österholm, p. 325).

**Summary of the Literature Review**

In summary, the studies presented offer empirical evidence that reading mathematics text is more complicated than reading other text. The main stumbling-block appears to be mathematics symbols (Österholm, 2006), technical terms, and the combination of visual representations (Lager, 2006). Some studies demonstrate effective strategies to teach students to read text in general and mathematics text in particular: reading aloud, or reading with pencil and paper (Adams & Lowery, 2007); explaining ‘double-meaning’ words and definitions, or using graphic organization of vocabulary (Carter & Dean, 2006); presenting text in different ways: writing, speaking, and drawing (Borasi et al., 1998); and, teaching students reading strategies that help them to read and solve mathematics problems from the textbook (Ostler, 1997). Other studies illustrate the effectiveness of using additional literature (e.g., mathematics-related text and children’s books) as a way of helping students to understand mathematics concepts and to engage them in reading (Adams & Lowery, 2007; Borasi et al., 1998).

The focus of this research is to provide a rich description of one teacher’s efforts to address the issues related to the incorporation of strategies and processes for reading text in his classroom with all students. In addition, this study presents one teacher’s own belief of teaching reading strategies which may help students to better comprehend mathematics course material by building a repertoire of strategies that may open the door to improved mathematics problem-solving, higher mathematics achievement and positive mathematics disposition. The research does not seek to establish any causality between the reading instruction and student achievement.
CHAPTER THREE: METHOD

Introduction

In this chapter, I describe the methodology of this study. I begin with a presentation of the rationale for the qualitative case study approach employed in this study. Next I present the participant selection criteria, the design of the study, and the methods of data collection which include interview, classroom observation, and document collection. I also discuss the strategies that I used for enhancing the trustworthiness of the study. At the end of this chapter, I explain the methods of data analysis.

Rationale for Qualitative Approach

The choice of either a qualitative or a quantitative approach mainly depends on the purpose and the research questions to be addressed (McMillan & Schumacher, 2006; Patton, 2002). Since the main purpose of this study was to describe reading strategies that one unique mathematics teacher uses in practice and to understand this teacher’s motivations to include reading in his regular classroom instruction, qualitative methods seemed most suitable. McMillan and Schumacher indicate that the purpose of qualitative research “is more concerned with understanding the…phenomenon from the participants’ perspective” (p. 12).

The principal purpose of my study was not to compare or measure the effectiveness of the teacher’s instruction, but to describe the ways in which reading strategies and reading-based activities are implemented in a regular mathematics classroom setting by an informed teacher who has, himself, extensively researched the topic of reading in the mathematics context, and then actively interpreted the research through self-generated or professionally adapted curriculum.

A qualitative approach very carefully searches for subjects of the study by using purposeful sampling that is driven by a desire for “in-depth understanding” (Patton, 2002, p. 46). According to Morse (1998), in a qualitative study, “[s]ampling occurs purposefully, rather than by some form of random selection from a purposefully chosen population, as in quantitative
research” (p. 76). In particular, this qualitative study adopted a case study approach. Stake (1995) stresses that qualitative case study “is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances” (p. xi). In addition, he mentions that a case study “is defined by interest in [the] individual case” (2005, p. 443).

My intention was to provide a greater understanding of one unique phenomenon—the mathematics teacher who strives to help students to develop their abilities to read text, and who strongly believes in teaching students how to read and how to apply reading strategies through his lessons in a regular and on-going way. Patton (2002) identifies such individuals as an extreme case, “those who were [are] exemplars of good practice,” (p. 234) and those who “are information rich because they are unusual or special in some way” (p. 231). In my study, this extreme case was deemed to be more likely to give me rich examples of classroom performances and answer my research questions than a case that was representative of mathematics teachers in general.

Data Collection Methods

Participant Selection

Purposeful sampling was used to find the illuminative case—the mathematics teacher who sheds light on the complexity of teaching reading strategies in the mathematics classroom (Patton, 2002). In order to answer my research questions, the following criteria were considered when selecting the participant: the participant must be a teacher of mathematics at an Ontario high school; the participant must regularly incorporate reading text in his classroom by using different types of text; the participant must be knowledgeable about reading strategies which can be used during instructional activities to teach reading of text in general and mathematics text in particular; and the participant must have strong beliefs about the importance of teaching students to read and comprehend text in general and mathematics text in particular.
The participant was selected based on a presentation that he made on topics related to this research. I attended his session at the annual conference of the OAME in May 2007. At this conference, I attended several workshops related to language in the mathematics context, specifically, sessions related to writing, and reading in mathematics classroom. Mr. Merle (pseudonym) presented a number of rich activities that supported reading in the mathematics context. He shared his experiences with integrating reading strategies in a Grade 9 Applied Mathematics course: instructional activities that included short stories, magazine articles, and vocabulary graphic-organizers. In the workshop, he mentioned that he would continue to learn more about this issue and would like to continue teaching students to read in his classroom by refining and supplementing the materials he had developed during his opportunities to teach Grade 9 Applied Mathematics. His presentation and his materials helped me to decide that he would be an illuminative informant according to the selection criteria outlined above.

Design of the Study

A case study approach is one way of conducting qualitative research. This means that data collection methods such as observations and interviews, which are common for any qualitative study, are applied to the particular case (Stake, 2005). The choice of data collection methods primarily depends on the research questions. In this study, interviews, classroom observations, and document analysis were deemed to be the most appropriate and informative tools for data collection. I used one or some combination of these methods to answer each of the research questions that I had posed.

The data collection phrase began on February 11th, 2008 and continued through to April 16th, 2008 taking place in the Ontario High School where I observed Mr. Merle’s Grade 9 ESL
(English as a Second Language) Academic³ mathematics class. Even though Mr. Merle taught a number of courses, data were collected exclusively from this particular mathematics course because of the participant’s stated preference that I observe this class. Mr. Merle stressed that it would be easier for him to present reading activities in this course because he was planning to refine and reuse the activities that he had developed and implemented while teaching the Grade 9 Applied Mathematics course in the 2006-2007 school year.

The process of data collection occurred in several stages. First, I met with the teacher in order to have him sign a consent form, and to establish possible dates for the interview and observation phases. I conducted the initial interview before my first classroom observation. During this interview I acquired a tentative schedule of classes in order to select the best possible opportunities for observation and follow-up interviews. Since the intent of this study was to describe the teacher’s practice of incorporating reading strategies in the mathematics classroom I used selection criteria to choose the richest lessons, i.e., ones that were most likely to feature instruction in or application of reading strategies.

The following criteria were considered to select lessons for observation: the lesson should be suggested by the teacher in terms of implementing reading strategies, and the lesson should include at least one type of reading strategy [e.g., vocabulary development strategies, reading ancillary text (including the mathematics textbook), and reflection]. My original goal was to attend at least one or two lessons in which each of these strategies figured prominently because I wanted to describe each of these three strategies in depth. For each of the negotiated lessons, I

³Two different mathematics courses are identified by the Ontario Mathematics Curriculum in Grade 9, e.g., academic and applied. The Grade 9 academic course is used to “develop students’ knowledge and skills through the study of theory and abstract problems” (Ontario Ministry of Education, 2005, p. 6) The Grade 9 applied course is applied for teaching “the essential concepts of a subject, and develop students’ knowledge and skills through practical applications and concrete examples” (p. 6). In addition to these courses, MOE documents provide locally developed courses to meet educational needs not met by provincial curriculum policy documents. For example, a Grade 9 essential course was designed to address students’ needs who “have experienced significant difficulties in previous mathematics courses” (Dallan et al., n. d., p. 3).
collected the teacher’s lesson plan and ancillary resources (e.g., handouts, worksheets, textbook references, journal articles, professional books, and children’s literature). After observing each of these lessons, at a convenient time for the teacher, I conducted a semi-structured follow-up interview using questions designed to elicit more explanation or clarification about specific instructional activities that were observed during the classroom session.

**Interviews**

In this study, the main tool for data collection was the semi-structured interview. I chose this type of the interview because it provides the researcher with structure for the main interview questions, while it helps to ask probing questions for deeper understanding of the teacher’s point of view (Patton, 2002). The initial interview lasted approximately 110 minutes and each of the six follow-up interviews lasted between 15 and 33 minutes. All were audio-taped. During every interview I took brief notes consisting of key words so that I would not distract the interviewee. These notes helped me to ask probing questions and to become familiar with the teacher’s vocabulary. During the initial interview, I asked the participant questions (see Appendix A) about his attitude toward teaching students to read mathematics text and about his experience of planning course materials and lessons designed to feature instruction or experience in reading mathematics text.

During each follow-up interview, I focused mainly on questions related to activities, reading strategies, and students’ reactions. This helped me to get a deeper understanding of the teacher’s rationale for selecting particular reading strategies or activities and to add more detail about the lessons. At the same time, the follow-up interviews gave me the opportunity to describe not only activities that happened in the lesson but also to record the teacher’s perspective.

Questions asked during the follow-up interviews were different from lesson to lesson; thus they were generated by my observation of the each lesson. For example, questions posed to the informant were similar to the following: “This activity took more time that you anticipated.
How will this affect the lesson for tomorrow?” or “I noticed when Jiao was trying to solve a problem at the blackboard, you asked him to read the mathematics problem aloud several times, and then asked “What does ‘square’ mean?” How important is it to keep the focus on mathematics vocabulary?” However, there were several questions that I asked during each follow-up interview: “What was the main goal of the lesson? What kind of literacy goal did you have for this lesson? Why was this topic particularly appropriate for the integration of a reading component? If you were teaching the same lesson, but with non-ESL students, how would the lesson change?”

Classroom Observation

I observed six lessons, each selected based on to the initial interview, my professional interest in particular resources that I had heard the teacher discuss at the OAME conference, and the teacher’s preference. During observations, I took notes to record all activities that happened in the classroom including a thick description of reading strategies, the teacher’s explanations, and the students’ reactions. However, the main focus of all classroom observations was the teacher since he was the case under study. The goal of classroom observation is to see the real activities of a teacher’s practice (Erickson, 1986). In addition, Patton (2002) argues that observation allows the researcher to better understand and capture the context, and to draw on personal knowledge of the situation when later interpreting and analyzing the collected data. In this study, the main reason for observing classroom activities was to be able to report the strategies that the teacher used with a full class while working with mathematics text.

After, my initial interview, I identified three reading strategies that the teacher used in order to teach reading text and facilitate students’ comprehension: vocabulary development (e.g., crossword puzzles, Word Wall bulletin board displays, and oral explanation of mathematical terms); reading supplementary text (e.g., children’s literature, poems, and the mathematics textbook); and reflection strategies [What do I know?, What do I want to learn?, What have I
learned? chart strategy (K-W-L), and writing]. The lessons were chosen to allow me to observe a minimum of one of these three reading strategies. Although my original research plan was to observe four to five lessons, I actually observed six 70 minute lessons in order to see all of the strategies in action and to reach saturation in my data. In table 1, I present the observed lessons and related reading strategies and reading-based activities.

Document Collection

Documents, which included lesson plans, ancillary instructional materials, and the mathematics resources employed by this teacher, provided a record of the teacher’s strategies for integrating reading activities into his lessons. My intention was to understand the range of ways in which reading strategies were integrated into the teacher’s lesson development and to find the connection between the purpose of the lesson and reading activities. These materials helped me to closely examine the literature, vocabulary graphic-organizers, or worksheets that the teacher employed to support reading in his classroom.

After the lessons, I collected the following materials: a template for integrating reading strategies in different units of Grade 9 Applied Mathematics course (e.g., Measurement and geometry, Number sense and algebra, and Linear relationships); children’s literature (Holes by Louis Sachar, The Village of Round and Square Houses by Ann Grifalconi, and Eighteen Flavors by Shel Silverstein); and handouts (see table 1). Mr. Merle also shared with me the materials that he developed for other lessons into which reading activities had been integrated but which I did not have the opportunity to observe in use first-hand. These supplementary handouts include: the Frayer Model template, ‘Part A: How Many Jelly Beans in the Fish Tank?’, and ‘The Science of Crowd Counting’.
<table>
<thead>
<tr>
<th>Lesson</th>
<th>Reading Strategies and Reading-based Activities</th>
<th>Collected materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>oral explanation of the problem</td>
<td><em>Textbook Scavenger Hunt:</em></td>
</tr>
<tr>
<td></td>
<td>introducing the mathematics textbook</td>
<td><em>Worksheet</em> (Appendix F)</td>
</tr>
<tr>
<td>2</td>
<td>K-W-L chart</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>oral explanation of the math terms and Word Wall</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>crossword puzzle and Word Wall</td>
<td><em>Crossword puzzle: Algebra unit</em></td>
</tr>
<tr>
<td></td>
<td>reading the poem—<em>Eighteen Flavors</em> by Shel Silverstein</td>
<td>(Appendix H)</td>
</tr>
<tr>
<td>5</td>
<td>reading the novel—<em>Holes</em> by Louis Sachar</td>
<td><em>Holes: Worksheet</em> (Appendix I)</td>
</tr>
<tr>
<td>6</td>
<td>crossword puzzle and Word Wall</td>
<td><em>Crossword puzzle: Measurement unit</em> (Appendix J), and <em>The Village of Round and Square Houses: Worksheet</em> (Appendix L)</td>
</tr>
<tr>
<td></td>
<td>reading the children’s book—<em>The Village of the Round and Square Houses</em> by Ann Grifalconi</td>
<td></td>
</tr>
</tbody>
</table>
Research Quality

McMillan and Schumacher (2006) indicate that the quality of qualitative research depends on the researcher’s abilities and data collection analysis techniques. Patton (2002), and Stake (2005) suggest different criteria for judging the quality of a qualitative study and strategies for enhancing the trustworthiness of the study.

In this particular study, I used triangulation of data sources (e.g., observation, interview, and document collection). This method increased the reliability of the study by collecting data from different perspectives, thus “different kinds of data have captured different things” (Patton, 2002, p. 560). Triangulation helped to find consistency of findings across data sources, for example, between teacher’s lesson planning and implementation of reading activities in his practice, between observed strategies in his classroom and his explanation of these strategies during the follow-up interview. Hence, the triangulation process provides additional information that helps to deeply understand the core of the issue and "illuminate various aspects of a phenomenon" (Patton, p. 559).

Patton (2002) indicates that one limitation of a qualitative study can be the nature and number of cases being examined. This means that it is important to clearly explain the choice of purposeful sampling and to report results in their context. According to Stake (2005), the detailed description of data gives the reader the opportunity to make an alternative interpretation and enhances the trustworthiness of the qualitative study. Thus, the researcher “has some responsibilities for the validity of the readers’ interpretation” (Stake, p. 453). That is why, in my study, I presented detailed criteria for choosing the illuminative case and in the chapter four ‘The Presentation of the Data’ I provide the reader with expansive description of the data.

Another strategy is the acknowledgement of the researcher’s biases. Patton (2002) argues that this acknowledgement minimizes the impact of subjectivity of the study. Hence, I presented my background and experience through the presentation of my own autobiographical signature as
one component of the ‘Context of the Study’. In this way, I would like to involve the reader in
discussion about "how one’s [the researcher’s] own experiences and background affect what one
understands and how one acts in the world" (Patton, p. 546). As I mentioned in chapter one, I was
a teacher of mathematics in secondary and elementary school in Ukraine. Because I have my own
experience, as a teacher, of trying to use similar strategies and activities for reading instruction, I
hold my own beliefs about and assessments of integrating reading strategies in mathematics
instruction.

McMillan and Schumacher (2006) suggest using a reflex journal which contains “the
available information at the time, of the modifications of the research problem and strategies”
(p. 329). This journal helped me to see the track of my decision making during the research and
alerted me to my own biases when describing what was happening in the classroom. I was
rigorous in my note-taking and regularly used the column in my field notes titled ‘my thoughts’ in
order to separate my personal and professional ideas from the events that I observed happening in
the classroom.

Other strategies that I employed, are related to the accuracy of the data collection phase:
audio taping interviews and making field notes during observation. For example, digital audio
recordings helped me to transcribe the interviews verbatim (McMillan & Schumacher, 2006;
Powell et al., 2003). I transcribed field notes immediately after each lesson because if I postponed
the transcription I would be more likely to forget specific details about the observed lessons. In
addition, I chose to transcribe my data by myself in order to be closer to my data and to facilitate
the data analysis phrase. However, after I transcribed all my data I asked my supervisor to look
over the transcribed data and to check them for accuracy and use of language conventions. The
purpose of doing this was because English is not my first language and I wanted to make sure that
all my interviews were transcribed correctly.
Data Analysis Methods

I analyzed the collected data in order to answer the research questions that will in turn achieve the overall research purpose. In a qualitative study, preliminary data analysis and data collection occur simultaneously. Thus during data collection I began analyzing data to realize the next step of data collection (Marshall & Rossman, 2006; McMillan & Schumacher, 2006; Merriam, 1988; Patton, 2002). This study utilized this approach, since I conducted a follow-up interview after each observation. This means that I planned data collection sessions according to what I had found in previous observations, lesson plans, or interviews. For example, I used preliminary analysis of the initial interview to choose appropriate lessons related to reading text or reading strategies, or I analyzed field notes of observed lessons in order to develop questions for follow-up interviews.

Because observations, interviews, and the teacher’s instructional resources were the main instruments of data collection; interview transcripts, field notes, and documents comprised the suite of collected data. The analysis of these data included two components: analyzing field notes and interview transcripts; and, analyzing documents. The process of analysis consisted of the following steps: organizing data; coding, developing categories, and finding themes; as well as evaluating data and searching for alternative interpretations (Marshall & Rossman, 2006; Merriam, 1988; Patton, 2002).

The phase of organizing data began with transcribing verbatim interviews and field notes. In total, I had 95 pages of transcribed interviews including the initial interview and seven follow-up interviews, and 18 pages of field notes from the classroom observations. I organized all my data in chronological order. For instance, for the first lesson I collected all data related to this lesson, including field notes, the teacher’s materials (e.g., handouts, lesson plan, and children’s book) and follow-up interview data. In total, I have six folders: one for each of the observed
lessons. In addition, I have a folder with all of the additional documents that Mr. Merle provided (e.g., handouts from classroom implementations that I did not have an opportunity to observe).

The second phase of analyzing the data was related to the process of coding, categorizing and developing themes. Patton (2002) mentions that qualitative research typically embeds an inductive approach which starts with open codes when the researcher creates the codes, categories, and themes which come directly from the data. However, there is also a deductive approach to the analysis in qualitative research when the researcher examines the data by applying the theoretical framework (Patton). In my analysis, both of these methods were used:

\[\text{once patterns, themes, and/or categories have [had] been established through inductive analysis, the final, confirmatory stage of qualitative analysis may be [was] deductive in testing and affirming the authenticity and appropriateness of the inductive content analysis, including carefully examining deviate cases or data that do not fit the categories developed. (p. 454)}\]

Inductive analysis helped me to generate categories and themes that emerged from the data and deductive analysis provided an opportunity to confirm the developed themes and helped me to collapse some of the categories into more comprehensive themes.

First, I read all transcribed materials in chronological order to get a sense of the data. Next I read the transcribed data carefully several times in order to find units that related to my research questions and the purpose of the study. After outlining possible units, I began to work on coding units. After coding each of the units (30), I collapsed them into categories (10) and then by seeking out similarities, I combined some categories to generate the themes (4).

I separately created codes and categories for each interview. For example, I developed codes and then categories that emerged from the initial interview, and then I did the same for each of the follow-up interviews individually. I created a chart with codes and relevant quotes from the data which helped me to find a pattern and collapsed these codes into the categories, and then called them into the themes. When I transferred quotes from the raw data to this chart, I indicated the interview, and page number from the raw data. I generated abbreviations for the interviews to
facilitate access to the data, e.g., the initial interview—II, follow-up interview #1—FUI1, and so on. I also used abbreviations for the classroom observation field notes, e.g., the field notes from the lesson #1—CO1. After developing codes for the initial interview I came up with 29 codes. I read the transcripts again, and reduced the codes to 22. After that I looked over my data and codes again and sorted the codes into categories. I did the same with each of the follow-up interviews (12-16 codes). The codes were similar throughout all follow-up interviews which made it easier for me to analyze and develop categories.

After I finished the inductive analysis and had developed themes, I referred to my theoretical framework (Merriam, 1988) which helped me to separate one of my themes into two and to confirm the importance of these themes for my study and for mathematics education research in general. Before developing final themes I went through all of my data once more including the initial interview, all follow-up interviews, and classroom observation field notes, with the goal of analyzing across the data to make sure that I had not missed putting any categories or codes into the themes. As a result of this exhaustive process, I generated three main themes: teaching practice that has been informed by research; the role of context; and challenges to implementing reading instruction in the mathematics classroom (see table 2).
<table>
<thead>
<tr>
<th>Themes</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Role of Context</td>
<td>Needs Arising from the Specific Course; Contextual Influences Unique to Mr. Merle: (a) Educational Background and Teaching Experience; (b) Factors that Motivated Mr. Merle to Include Reading Strategies in his Practice; (c) The Unique Experience of Teaching Mathematics with Reading Emphases.</td>
</tr>
<tr>
<td>Challenges to Implementing Reading Instruction in the Mathematics Classroom</td>
<td>Mr. Merle’s Challenges in Integrating Reading Strategies: (a) the Grade 9 Applied Mathematics Course, (b) the Grade 9 ESL Academic Mathematics Course; Mr. Merle’s Suggestions for Encouraging Mathematics Teachers.</td>
</tr>
<tr>
<td>Teaching Practice that Has been Informed by Research</td>
<td>Mr. Merle’s Explicit Goal-Setting; Classroom Implementation: (a) Instruction of General Reading Strategies, (b) Instruction of Reading Strategies Specific to Mathematics Text.</td>
</tr>
</tbody>
</table>
The last stage of data analysis was the analysis of the collected documents. I analyzed documents such as lesson plans, textbook chapters, and supplementary materials (e.g., handouts, worksheets, journal articles, books, and short stories). According to McMillan and Schumacher (2006), there are several ways of analyzing artefacts. In my study, I made a brief description of these materials, the frequency and the purpose of their use, and the way they were practically implemented during the lesson. McMillan and Schumacher mention that the interpretation and analysis of artefacts should be corroborated with field notes and interview data. For example, while analyzing books, short stories, and handouts I presented a brief description of these materials including some of the teacher’s explanations (taken from an interview, e.g., how Mr. Merle developed some of the handouts, how often he used them, why he chose these books for reading in his classroom). While analyzing lesson plans and the teacher’s implementation chart for reading strategies, I also recorded all topics of lessons, the frequency of integration of reading instruction, and assignments related to reading.

After all categories and patterns were created, I worked with these findings to evaluate the data and to seek possible alternative interpretations. Patton (2002) claims that “interpretation means attaching significance to what was found, making sense of the findings, offering explanations, drawing conclusions, extrapolating lessons, making inferences, considering meanings, and otherwise imposing order” (p. 480). I used the major categories and themes in order to make connections between the purpose of the study, and my data. During the interpretation phrase, I used knowledge from the theoretical framework and literature review to provide a robust explanation about what happened in the classroom. Interpretation brings meaning and coherence to the categories and themes, and gives the researcher opportunities to find alternative interpretations of the data (Marshall & Rossman, 2006).
CHAPTER FOUR: PRESENTATION OF THE DATA

Introduction

In this chapter, I present an organized account of the data that were collected through the study. This chapter consists of several sections: the first section describes the participant of the study Mr. Merle. I describe his background, the influences that led him to focus on reading strategies, and, the challenges that he faced during his attempts to integrate reading in his regular mathematics classroom program. The second section presents a description of the settings, including an outline of the Grade 9 ESL Academic Mathematics course and a portrait of the Grade 9 ESL class in which this study took place. In the third section, I describe Mr. Merle’s experiences with designing the course and organizing lessons to include different reading strategies.

In this chapter, I present data according to the categories and themes that emerged from the analysis of the data. To illustrate these categories and the synthesis of my analysis, I included data from both initial and follow-up interview, fieldnotes, as well as ancillary materials from the teacher. The presentation of data varies by section. For example, in the third section I took data from both the classroom observations and the immediate follow-up interviews because these two data sets provide the most complete picture of the teacher’s practice.

Participant

Background

Mr. Merle is a full-time mathematics teacher at a secondary school in the Greater Toronto Area (GTA). He has been a staff member at this school since September 2006, when he was hired as the head of the mathematics department. Mr. Merle has been teaching mathematics for 12 years in Ontario, and has taught at an independent all-girls school, in a secondary school in a small city within a public school board as well as in two high schools in the GTA. Throughout his career, Mr. Merle has taught a range of mathematics courses including Essentials, Applied and
Academic Mathematics (under the current curriculum policy), and Advanced Mathematics (under Ontario Schools: Intermediate and Senior [OS:IS]). In the second semester of the 2007-2008 school year, Mr. Merle was teaching two courses: Grade 12 University Advanced Functions and Grade 9 ESL Academic Mathematics. In addition to his teaching duties and responsibilities as the Head of the mathematics department, Mr. Merle served on a number of school committees including the Literacy Committee, the School Planning Committee for Continuous Improvement, and the Data Collection Committee.

Mr. Merle’s educational background includes a Bachelor of Science (Honours) degree in Applied Mathematics; a Bachelor of Education with teaching certification in both mathematics and science; and, a Master of Education degree in curriculum studies. Mr. Merle is currently working towards a Master of Arts (in Teaching Mathematics) degree at another Ontario university after transferring from a PhD program in mathematics education at the same university. He is also an in-service instructor for additional qualification courses offered to educators through the continuing education department of an Ontario university: teaching Intermediate, Senior, and Honour Specialist Mathematics courses in an on-line format.

Mr. Merle is actively involved in the Ontario mathematics community and beyond. Mr. Merle was a long-serving member of two editorial boards (the OAME Gazette and the NCTM Teaching Mathematics in the Middle School journal). Mr. Merle regularly attends local, provincial, and national conferences such as the OAME and NCTM where he not only has opportunities to learn more about the latest developments in mathematics education, but also has opportunities to meet with both peers and educational leaders (e.g., mathematics professors, mathematics education professors, MOE education officers, school district consultants and coordinators) who share similar teaching and research interests.

It is important to note that not only does Mr. Merle regularly attend mathematics education conferences, he is a respected and frequent workshop leader, voluntarily sharing the
resources he has developed and the results of his action research through workshops and presentations. Additionally, Mr. Merle often conducts professional development (PD) seminars, both at the school where he is currently teaching, and in both pre-service and in-service teacher education classes at local Faculties of Education (at the invitation of the instructors).

Mr. Merle is also unique from the perspective that he continuously conducts action research studies in his own classroom, i.e., Mr. Merle routinely uses his classroom as a mathematics education laboratory. After a three year action research program focused on journal-writing with his own mathematics students, Mr. Merle applied to a PhD program to formalize his: “[long-term] interest in mathematics communication...by studying written communication [using empirical methods]” (II, p. 1).

During an NCTM regional conference in 2002, Mr. Merle had an opportunity to meet Dr. David Pugalee, a faculty member at the University of North Carolina (Charlotte), whose research interests also relate to integrating literacy in the mathematics classroom. While most of Dr. Pugalee’s published research focuses on writing in the mathematics classroom, his most recent work examines studies of reading strategies in the mathematics classroom. This serendipitous meeting resulted in an on-going, long-term professional collaboration. Professor Pugalee has supervised each of Mr. Merle’s action research studies: the first, related to student journaling in mathematics class, and the second about integrating reading strategies in a Grade 9 Applied Mathematics program.

The Influences that Led Mr. Merle to Include Reading in his Regular Classroom

Mr. Merle has been focusing on mathematical communication in the mathematics classroom for almost six years, when he first began exploring journal-writing as a vehicle for teaching and learning and assessment in the mathematics classroom. After three years of studying writing as a tool for communicating student understanding, he turned his attention to another literacy component: “This reading emphasis stemmed out of my interest in writing” (II, p. 1).
Mr. Merle’s action research study led him to conclude that journal-writing led to improved mathematical written communication and deeper understanding of mathematics concepts: “I saw the benefits from writing by using journals in mathematics…. [T]he kids explain step by step how they solved the problem or whatever. I saw so much good in that and the kids really bought into it” (II, p. 2). The success of his journal-writing teaching experiments made Mr. Merle hopeful for similar benefits from and responses to a focus on reading.

Mr. Merle’s first implementation of reading was in a Grade 9 Applied Mathematics classroom during the 2006-2007 school year. It was this particular action research study that convinced him of the potential benefits from facilitating this mode of students’ mathematical communication. Recognizing that many of his students were inexperienced in mathematical communication skills and processes, Mr. Merle decided to include both reading and writing as a priority in mathematics class, because he believed that doing so was his responsibility:

I [learned a lot from] the study I did with the 9 Applied class, with reading. It was a special class [in which] students had many communication disabilities. My role was to provide accommodations in terms of the communication category on [the provincial achievement chart]. (II, p. 3)

Mr. Merle emphasized that mathematical communication (e.g., speaking, reading, and writing) is not just a vision for mathematics education but an expectation: i.e., “[t]hrough the NCTM Standards…communication is a standard and also now the Ontario [Curriculum] document’s mathematical processes list [specifies] communication as one of the [process] standards” (II, p. 1).

Another driving force for Mr. Merle was the MOE requirement that all students must pass the Grade 10 Ontario Secondary School Literacy Test (OSSLT) in order to earn an Ontario Secondary School Diploma. Mr. Merle said that the compulsory nature of this test puts pressure on all subject areas to focus on literacy, and on all subject teachers, not only English specialists, to include literacy as an important component of instruction (II, p. 2).
Another province-wide test that caused Mr. Merle to strive to help students to better comprehend mathematics text was the annual provincial assessment of Grade 9 mathematics by the Education Quality and Accountability Office (EQAO), which, although compulsory for all Grade 9 students, is not a graduation requirement. Mr. Merle explained that in order to be successful on the Grade 9 test, students should not only know mathematics facts, rules and procedures, but also have the ability to read and comprehend mathematics word problems and write explanatory text detailing their problem-solving strategies. The test was a catalyst for Mr. Merle to think about practical strategies that he could employ within the regular program to help his students meet the provincial standard on these tests:

[The]EQAO test is very wordy. Sometimes...when we do EQAO, I am thinking: “Are they testing math or they are testing language?”... Sometimes, [even] I have to read the questions a couple of times. But [even though] the EQAO test has gone through validity tests...to make sure that the language is at the right grade level...still kids don’t get it.... Sometimes when I read the question myself...[I] do not really know what they want and if I have to second guess sometimes, then I wonder what students are doing. I really worry, especially for this group. It is going to be a real, real challenge for them because [they have to learn] not only the math...but also how to write an EQAO test. (FUI1, p. 2)

In spite of his level of expertise and knowledge of the professional literature about issues in mathematics education, Mr. Merle maintained a healthy skepticism about integrating something new in his own classroom. Before incorporating a non-traditional teaching or assessment practice, Mr. Merle routinely seeks empirical evidence to support the notion that the innovation could help students improve their results in mathematics. Mr. Merle admitted that Professor Pugalee’s reputation and program of research convinced him of the efficacy of his mentor’s claim that: “there is a correlation between reading comprehension and mathematics achievement” (II, p. 6). Motivated by this assertion, Mr. Merle was determined to find other research that supported the idea that reading strategies could positively influence students’ mathematics achievement:
through those kinds of things that I have read that I can say: “What should I be doing?” (II, p. 2)

Fortunately, Mr. Merle had enormous support for integrating literacy strategies in his mathematics classroom from the principal of his school, Mrs. Ying, during her tenure. Mrs. Ying has an EdD from an Ontario University where she focused on issues related to teaching ESL students. She enthusiastically endorsed Mr. Merle’s efforts to incorporate reading in the mathematics classroom, and invited him several times to share his experiences with colleagues through PD seminars at the school:

[t]he principal...wanted me to share these strategies with the other teachers in the school because one of the priorities for the year was literacy...[it is] a cross curricular [responsibility] because...we have the Grade 10 OSSLT. So, we are accountable in each department to promote literacy. (II, p. 34)

Mrs. Ying encouraged Mr. Merle to be a ‘lighthouse teacher’ for literacy-across-the curriculum because he had a menu of practical ways in which subject specialists could embrace topics that were traditionally not seen as important components of content-based courses.

Mr. Merle welcomed the opportunities provided by this principal, especially to provide PD sessions in his own mathematics department. Mrs. Ying believed that Mr. Merle was an excellent choice to be a literacy-across-the-curriculum advocate and mentor:

she wanted me to be a role model to the other teachers and show that you can implement reading and writing strategies but you do not have to have a literacy background, like a formal literacy background. So, it is okay, you can do it with supports. (II, p. 9)

Mr. Merle told me that although he did not have a formal literacy background and had taken no additional qualifications courses on the topic, he made it a personal and professional priority to learn about and implement reading in mathematics.

Because of his leadership responsibilities in the school and the mathematics education community, Mr. Merle often was away from his classes and he noticed that assigning students the task of reading their mathematics textbook, and then answering questions based on this independent study was futile. After an absence, Mr. Merle could not move on since:
the work was not done because the kids would complain they did not understand it. So, that kind of information triggered to me, “[t]hey do not get it,” so I was forced to ask myself “What can I do as the classroom teacher to make them get it?” (II, p. 1)

When I asked Mr. Merle what would be lost in his classroom if he stopped teaching reading, he answered “what would be lost would be any real efforts to read as well as comprehension of the text” (II, p. 2). Mr. Merle posited that it was important to integrate reading strategies and help students to read, first of all because of the unique characteristics of mathematics text and the representations of content in the mathematics textbook:

research is emphasizing the importance of reading in mathematics. The idea of that is that mathematics text is very difficult to read. It has its own vocabulary, its own symbols, [and] its own language and we cannot assume that kids will just pick it up, read it and get it. (II, p. 1)

In addition, Mr. Merle stated that the goal of modelling how to read the text and showing students what strategies to apply was to help them to extract meaning from the text and to encourage them to use these lifelong learning strategies in other contexts:

the intent is to...help them to get access to what they read, whether it is in the textbook, whether it is in the newspaper, whether it is in the short story or whatever. Because the idea is [that] at the end of this all [their experiences in studying reading strategies] they will...be able to read...on their own and have strategies in place. (FUI2, p. 11)

Mr. Merle saw a strong connection between teaching reading aspects of the communication process strand and problem solving:

I think communication and problem solving is really important and [mathematics teachers should] make it as a priority.... Because we want kids to problem solve...[and] I think communication is like another tool for word problem solving.... In order to learn mathematics we need to read and write. I do not think that communication is something that you do sometimes, and do not do other times. I think it has to be done all the time. (II, p. 4)

When Mr. Merle began working with ESL students he realized that: “some of these strategies may be beneficial for all [students], but they are essential for some.... These reading strategies are essential for these 9 ESL kids” (II, p. 8). He recognized that this course especially should be focused on literacy, and, in particular, on reading. To this end, Mr. Merle told his students at the beginning of the course “we need to focus on the language, we need to understand
the language and [we need to learn] how to read…because that is going to help us to learn mathematics [concepts]” (II, p. 8).

Because of the background of this particular group of students, Mr. Merle was very concerned because the students seemed to be struggling with reading and writing in general. During my classroom observations, I witnessed numerous occasions on which the students turned to their first language in order to ask peers from the same country to translate particular mathematics definitions (CO1, CO2, CO3, CO5, CO6). Mr. Merle recognized an urgent need to help these students to read and comprehend the mathematics text and at the same time give them opportunities to communicate in English in his mathematics lesson:

I really want to get at reading with them…to teach them to interpret charts, graphs…and…. While we are doing that it also helps them to develop their language and get them to speak in class and talk with one another in English. (II, p. 16)

While teaching ESL students, Mr. Merle found that he needed to emphasize vocabulary development. Through the diagnostic test (CO2), he noticed that most of the students could not solve word problems because they had no experience with the mathematics terms used in the problem statement. This underscored for Mr. Merle that ESL students needed to have unique accommodations to facilitate their learning of mathematics in an English classroom environment. In his opinion, the use of explicit reading strategies in instruction was included in the set of appropriate accommodations.

Mr. Merle did find that teaching reading strategies in his mathematics classroom changed the teaching and learning dynamic. He pointed out that these strategies had a dual effect on his mathematics teaching. On one hand, he was teaching how to write and read but, on the other hand, he believed that he was enriching the presentation of the mathematics concepts:

we want to dig deeper into mathematics [concepts] as opposed to just [develop] skills and procedures. What we want to change is the nature of mathematics and start moving towards more solving problems and reading has an important role to get there. (II, p. 3)
He added that without reading strategies, especially, but also without assignments based on children’s literature, he would be less likely to provide students with opportunities to develop a conceptual understanding of the mathematics: “I do not think I could have given them the mathematical experience of digging deeper without [integrating] literature” (II, p. 27).

Furthermore, Mr. Merle pointed to the fact that using mathematics problems generated from reading children’s literature provided students with interesting mathematics facts, helped them to see connections between mathematics and the real world, and to experience the application of mathematics concepts to other contexts. To illustrate this, Mr. Merle described several examples and the rich mathematical opportunities they generated.

For example, one of the stories from the book *Sticks* by Joan Bauer (1996) is about a $100 gift-certificate that can be won if a contestant can guess how many jelly beans fit into a fish aquarium. After reading this story, the assignment for students was to estimate how many jelly beans could fit into an aquarium and a potato chip canister using both hands-on methods (i.e., using a small number of real jelly beans) and formulae (see Appendix C). Mr. Merle’s contention was that these kinds of assignments made students think beyond the abstract formula and understand how this formula works in practice:

the students may have memorized the formula for the volume of the cylinder as $\pi r^2 h$ but that does not mean they understand where the formula came from, but with the *Sticks*’s experiment, [w]e now dig deeper into it [because] we are looking at the application of the formula in a context.... By answering “How many jelly beans would be in the aquarium?” first, we can extend the problem-solving to Fermi problems such as “How many whatever can fit into our classroom?” (II, p. 12)

In another example using children’s literature, Mr. Merle read the book *Wilma Unlimited* by Kathleen Krull (1996) about a girl who was told that she would never walk again yet overcame the odds, first crawling, then hopping, next, walking, and finally running. The assignment emerged from this story was for the students to go outside, and hop, walk, and run 40 meters, in order to collect data to study rate of change: “looking at the real-life context and looking at the rate of change in terms of different ways of moving, that was the connection” (II, p. 6).
Another example of using supplementary text was a task based on a newspaper article from the Toronto Star (Appendix D). In this article—The Science of Crowd Counting, the organizers of a Toronto Protest Rally race reported that the size of the crowd was 115,000 yet the police department reported the number at 75,000. The rally organizers blamed the police department for miscalculating the crowd. The police department retorted with a defence of their estimate, presenting the calculations they used based on a known fact about the number of people that can fit into one square metre. Mr. Merle stressed that this kind of article convinced students that mathematics is everywhere, “this measurement stuff, which we did…has real relevance to the real world. Here is an article from ‘The Toronto Star’ that proves it” (II, p. 32). Mr. Merle also pointed out that exercises and articles like this help to improve mathematics students’ disposition towards the subject and their attitudes towards learning mathematics:

traditionally when we [are doing]…the measurement unit in Grade 9, we do develop the formula, but [the reality is that]…all the kids are doing is just plugging values into the formula, like find the surface, like find the volume of the ball, if they know the radius…. [T]hey can find it, [they can] find the area of such and such…. [However] an answer is all they get out of it, it does not sound too engaging to them or too relevant to them. (II, p. 32)

The nature of the tasks that emerged from the activities based on children’s literature were atypical for the secondary mathematics class and provided opportunities for students with different ways of learning to succeed. For example, Mr. Merle described an assignment that required students to be physically active or to act out a problem. This assignment was based on The Tell-Tale Heart by Edgar Allan Poe (1938), a short story about a man’s beating heart. He read an excerpt of the story aloud to students then led a discussion about how the man’s heart rate changed as a function of his emotions:

when the guy is resting, the heart is beating slowly… When he is really, really excited the heart rate goes up and up… then he dies. So, [the question for this story would be:] “What happened to the heart beat? (II, p. 33)

After reading this story he asked his students to use motion sensors, timers and other probes connected to graphing calculators as they walked, rested, walked quickly, walked forward,
walked slowly and walked backwards, generating, as a result, a piece-wise graph of a person’s heart rate. These opportunities, he said, engaged “kinaesthetic learners giving them a chance to see that math class is not just sitting and listening, and calculating...for no apparent reasons” (II, p. 6).

Mr. Merle divided reading strategies into three categories, e.g., vocabulary development, reading supplementary text, and reflection strategies. Each of these classifications featured prominently in his teaching repertoire. For example, vocabulary development strategies made mathematics more accessible and opened the door to problem solving success:

> when kids understand the vocabulary, it really has an effect on [learning] mathematics. Because if they do not understand what they read or what the word problem is [about] then how they are going to answer it. [T]hey will not be able to. (II, p. 7)

Reading supplementary text “helps the kids to do the mathematics we are teaching them and to learn the mathematics by succeeding on the problems” (II, p. 35).

Another reading strategy, reflection, helped Mr. Merle to enrich his diagnostic assessment strategies and gave students the opportunity to reflect on their own thinking.

Mr. Merle used a K-W-L chart ⁴ activity as one of reflection strategies. Mr. Merle found that the most significant columns for his purposes were *What do you know?* and *What have you learned?* He used the first column as a diagnostic assessment which helped him to determine starting points as well gaps in student knowledge that may exist at the start of the unit:

> K-W-L gave me a data as a classroom teacher [that] maybe I have a class [of students]...that does not need an extensive review [of previous content] or I have a class that needs a lot of review because they did not learn it before.... The assumption that they know everything is not always right. We need to get to the answer to “What do they know?” (FUI2, p. 5)

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⁴The K-W-L chart was invented by Ogle (1986) as a reading activity. This chart consists of three columns which represent “the three basic cognitive steps…. accessing what I know, determining what I want to learn, and recalling what I did learn as a result of reading” (p. 565).
According to Mr. Merle, “What have I learned?” helped students to self-assess by encouraging them to take ownership for what they had accomplished during the unit and what they still needed to learn. The K-L chart provided an:

opportunity for them to reflect. Filling it out means that you sit down and actually start thinking about: “What did I learn?” Because the idea is…if you yourself know you have then [you need to ask yourself:] “What am I going to do about it? (II, p. 14)

Challenges to Integrating Reading Strategies in the Mathematics Classroom

The lack of appropriate support for mathematics teachers. One half of my initial interview was dedicated to questions about the challenges faced by Mr. Merle to incorporating reading strategies into his program. When I asked Mr. Merle to describe the challenges he had encountered, he replied that they were numerous. One of the challenges that Mr. Merle’s cited from his experience of implementing reading was that “it is really hard to implement these new initiatives, if you are doing it in isolation” (II, p. 11). By isolation, Mr. Merle was referring to a situation in which he, himself was trying to integrate a new practice but had no local colleagues who shared an interest in this topic or with whom he could collaborate.

To illustrate this, he provided several examples. He explained that if his action research passion was technology, he could find lots of peer support because “teachers have embraced technology in terms of graphing calculators” (II, p. 23) because these were tools explicitly built into the curriculum and into the provincial assessments and because teachers could see first-hand the benefits of using technology immediately in their own classrooms:

there are…lots of mathematics teachers showing us how they use the technology in the classroom, [and] teaching us the benefits of it and that makes more of us use it. But, [for] these things like reading and writing…there are only one or two voices. So, definitely the isolation [in terms of opportunities to collaborate] is a barrier. (II, p. 5)

To emphasize his point, Mr. Merle noted that at the provincial mathematics education conference (i.e., OAME), an event held over 3 days for about 1 200 delegates, and an important source of teacher professional development in Ontario, there were only two sessions about literacy themes
in addition to his own presentations. Most presentations focused on integrating technology (II, p. 36).

According to Mr. Merle, there was hope for literacy to become a priority. He believed that communication had recently become a timely topic and that some schools were beginning to organize their own general PD seminars to educate teachers about how to incorporate writing or reading into teaching practices. However, what Mr. Merle noticed was that none of these seminars were specific to mathematics teachers. He pointed out that to be effective, these seminars needed to be subject specific and related directly and practically to mathematics teachers’ practice:

[in the PD seminars or school meetings] we are getting English consultants [who are] talking to the staff [mathematics teachers] …but [these consultants do not answer questions which mathematics teachers might have, for example:] “How would you put it into practice?” [or] “Do you see literacy as an important part of your course?” [because in those kinds of seminars] …there are no examples [for mathematics teachers]. That is the kind of PD [that we have]…. It needs to be subject specific in which teachers can see some relevance to them and what they [can] do in their classroom…they really need to have [someone] who shows them how it helps kids to learn mathematics. That is what mathematics teachers want to see. (II, p. 36)

*The nature and demands of the current mathematics curriculum.* Another barrier was addressing curriculum expectations and literacy in the mathematics classroom. Mr. Merle always maintained that the urgency for teachers is to address mandated curriculum expectations, especially the first time teaching the course. Once a teacher figured out what to teach, he or she could focus on other priorities such as literacy: “when you get a handle on the curriculum then you can start fine-tuning your lessons to include reading” (II, p.36). Furthermore, he mentioned that mathematics teachers in Ontario, over the past ten years, had been struggling with implementing continually changing curricula and textbooks. Mr. Merle said that if the curriculum was static then perhaps teachers would be in a better position to embark upon other innovations such as the integration of reading in mathematics class (II, p. 36).
Mr. Merle cited an example from the new curriculum for Grade 12, which specifies that mathematics teachers must teach Rational Functions as part of the Algebra unit. He told me that his department members, individually and as a team, spent many, many hours devising lessons to teach rational functions through the algebra lens, because previously this topic had been included in a particular calculus unit (II, p. 36). Moreover, since the accompanying mathematics textbook for Grade 12 had not yet been published, Mr. Merle asked, “where were teachers to turn to find resources and supports?” (II, p. 11). Mr. Merle stressed that he understood that mathematics teachers were heavily burdened with the day-to-day demands of teaching the new curriculum and did not blame them for not embracing literacy strategies as their priority: “literacy is an important priority but it is not as important as implementing the revised mathematics curriculum...that is really what is on the people’s minds right now” (II, p. 11).

The dearth of accessible resources. Another challenge that Mr. Merle encountered in his efforts to integrate reading strategies was to find expert-developed, research-based resources that provided him with practical examples, explicit instructions, and concrete step-by-step lesson plans that had been classroom-tested. Although the MOE has been advocating for literacy to be taught in all subject areas and supports the vision with professional documents such as ‘Think Literacy: Cross-Curricular Approaches Grades 9-12’, Mr. Merle believed that resource availability did not match teacher need: “it is a good document...but...it is the only document” (II, p. 5). If a teacher’s focus was on vocabulary development then the ‘Think Literacy’ document contained concrete suggestions; however, if the teacher wanted to integrate more sophisticated reading strategies or use supplementary text in their program, then they would need to find additional references and resources on their own: “So, if you [as the mathematics teacher] want to...[ask students to read] a newspaper article, you have to find it and design an exercise around it” (II, p. 5).
One of the professional books that Mr. Merle found to be most useful was *Math and Literature: Grades 6-8* by Bay-Williams and Martinie (2004) (MLG). He stressed that this book is very useful not only because it features fully developed lesson plans but also because it includes samples of students’ work. However, he emphasized that he still faced the difficulty of locating professional books and children’s literature. Mr. Merle said that he had to look over a mountain of professional and children’s books in order to find those that had rich mathematical connections and reading emphases (II, p. 6).

Mr. Merle believed that a good way to locate resources was on the advice of others. For example, he learned about *Sticks* by Joan Bauer (1996) when Professor David Pugalee told him about connections that could be made between the book and the topics of volume and interior angles. Nonetheless, there were no existing models to guide the development of his own lesson and materials.

Another challenge, according to Mr. Merle, was that there were two different types of children’s books: one type written by mathematics educators specifically to illuminate particular concepts via interesting contexts and others that were not written with any mathematical goals in mind yet opened the door to rich opportunities for posing mathematics questions:

*Mathematics Fingerprints* by Theoni Pappas and *The Greedy Triangle* by Marilyn Burns were written by mathematics educators who use the lens of mathematics to write the story…. These mathematics educators are writing...for a mathematics teacher audience. But when you look at books like *Holes*, it took a mathematics person to uncover the mathematics in it…it wasn’t planned. *Sticks* is another story that just happens to have mathematics below the surface. (FUI5, p. 5)

According to Mr. Merle, it is extremely difficult to identify children’s literature with mathematical possibilities that are appropriate for a high school audience compared to books geared to elementary school students. For example, mathematics educator Marilyn Burns has published a number of children’s books which present mathematics themes in fictional contexts. Her books are excellent curriculum matches for the elementary mathematics curriculum, but she has written nothing that applies beyond the Grade 6 level. In order to find appropriate
complementary/supplementary materials, a mathematics teacher would need to be a voracious reader of newspapers, fiction and non-fiction books, and magazines because only then is he likely to encounter text that has mathematical connections and possibilities.

Another obstacle that Mr. Merle found while implementing reading was how to assess the reading activities. Mr. Merle could not find any guidelines in the literature about assessing this particular aspect of his mathematics program; therefore he was trying to come to terms with issues and practices on his own: “[t]he issue is assessment. The questions are: “How would I assess it [reading strategy]?” “Do we need to assess it?” and “Should reading assessment in math be only formative…a way to see how they [students] are doing or Should it be summative…for a mark?” (II, p. 33).

Inadequate teacher’s background. In spite of his success in using literature and reading activities in his mathematics program and in the pre- and in-service teacher education courses, Mr. Merle still doubted his own efficacy: “I do not have a literacy background…. I do not want to be the blind leading the blind and be seen as someone who does not know what is going on, basically” (II, p. 9). Mr. Merle said he would be more confident if there were resources which were developed by other experts so that he could compare his materials to an external standard: “[I]t is really all about having other people develop resources. That could give me a big push to develop my own resources” (II, p. 35). In addition, already-developed recourses would help him to remove the burden of the lack of time. “[T]his is not the only one course I am teaching. I also teach other courses, and I am also the Head of department and I also have responsibilities to the department and I do a lot of administrative [work]” (II, p. 6).

Mathematics teachers’ attitude toward integrating reading strategies. Mr. Merle recognized that much of his motivation was based in his commitment to the action research process and its intrinsic rewards:

if it was not for me wanting to conduct these action research study [integrating reading strategies in a Grade 9 Applied Mathematics course] where I formally documented them
[reading strategies and reading-based activities] and I wanted to make it work. So, I had to find these things [e.g., materials and resources]. (II, p. 6)

He acknowledged however, that other teachers may need an extrinsic reward before investing the time and effort to experiment with literacy interventions: “if it is not for a graduate course or there is not something [like an additional teaching qualification or a certificate] that they gain out of it at the end” (II, p. 11), then what is the motivation for trying?

Mr. Merle emphasized that although mathematics teachers knew that integrating literacy should be an important component of their practice, they were entrenched in a comfortable style of teaching based on a traditional approach focused exclusively on subject matter:

some teachers do not still believe...even though the Ministry tells them that literacy is cross-curricular and everybody’s responsibility that they need to do it [integrate literacy instruction]...because they’ve always experienced mathematics without literacy. So they say: “Why would you want to change [your teaching practice] if it worked so well for you?” (II, p. 35)

On the other hand, Mr. Merle strongly believed that if mathematics teachers could see convincing evidence from other teachers about the benefits of integrating reading strategies into their program, and were given exemplary classroom-ready materials to use, teachers might be more likely to try themselves. Mr. Merle believed that teachers trusted teachers “I shared my resources...with the mathematics teachers, and they have been well received. I think teachers appreciate when someone else has identified something for them and...has shared students’ samples, or stories about the success of their experience” (II, p. 33). However, he remained cautious because unlike other innovations (such as technology) teachers would not see the impact of the implementation on student achievement and attitude right away. Thus he advised them to “give it [reading strategies] more than one shot and start small. [They should] try one thing out by themselves and see what effect it has” (II, p. 7).

Students’ resistance. Mr. Merle commented that some students could not understand why they were reading in the mathematics classroom, claiming that they could not see the connection between reading and mathematics. Indeed, I noticed in one of my classroom
observations that one student said “[T]his is not our English class. Why should we read it?” in response to being given a poem (CO4). Mr. Merle often encountered such responses from students. “[T]hey say this [reading activity] has nothing to do with math class so why we are doing it?” (II, p. 6).

Mr. Merle understood that resistance was a natural stage in any innovation, something he learned from his experiences in implementing journal-writing in mathematics class. During that particular action research study, Mr. Merle found that although the students demonstrated resistance during the first days of the implementation, as soon as they saw their own progress, and recognized that writing was helping their mathematics achievement, they began to enjoy writing.

With reading strategies, Mr. Merle noticed that students’ resistance depended on the kind of reading strategy implemented and the Grade. For example, using vocabulary development strategies would be inappropriate to do in Grade 12. (II, p. 8). Mr. Merle also noticed that some reading strategies generated more resistance than others:

if you get kids to do some of the other strategies which you know can be harder, [for example] K-W-L...that was frustrating for some of the kids, because K stands for ‘What do you know?’ and some of the kids did not know anything…. They did not want to finish the chart because it made them feel inadequate. (II, p. 9)

Some reading strategies, however, generated positive reactions (e.g., reading children’s literature, cross-word puzzles). This encouraged Mr. Merle to increase the frequency of their integration. What was unexpected to him was that students enjoyed reading children’s literature across grades and academic levels:

the kids find children’s books to be fun work because it is so engaging. [T]he books might lead to...measuring something...and they like that kind of stuff in the applied level. But I was surprised that even in academic level the kids really liked the activities. (II, p. 26)

Mr. Merle thought that a normal level of initial resistance would not be an issue in the particular ESL class under study because he was introducing them to strategies that students
could use in all of their classes, not just mathematics, and they realized that they had no option: “they know that they have to learn the language” (II, p. 8).

The Context and the Setting

The secondary school in which I observed Mr. Merle’s practice was a high school in the GTA in an area with a high immigrant population, the majority of which was Asian. The demographic of the student population resulted in high numbers of ESL students and led to ESL programs and literacy being major school-wide priorities. For example, in all years from Grades 9 to 12, the school offered credit courses in English as Second Language but unlike many schools in Ontario, there was also an extensive menu of locally developed courses: Beginners Communication in English, English in Daily Life, English for School and Work, Study Skills in English, and Bridge to English. In addition, particular courses combined ESL in the context of subject-oriented courses. In grades 9 and 10, ESL students had many courses designed specifically for them including Geography of Canada-ESL, Science-ESL, Principles of Mathematics Grade 9-ESL, Individuals and Family Living-ESL, Civics-ESL, Career Studies-ESL, and Principles of Mathematics Grade 10-ESL.

The classroom that I observed was a Grade 9 Academic Mathematics course for ESL students. This course was new to the school and to Mr. Merle. There were 17 students in the class from several different countries of origin. Some of the students had not attended school for the past two years (FU16, p. 6) and most of them were in the early stages of their English language proficiency development. It was a regular occurrence for students to speak to each other in their first language during seatwork opportunities. According to Mr. Merle,

the students were put into Grade 9 Academic ESL math class solely on the condition that they were ESL [students]. No one checked their mathematical background or ability: “I believe that at least 30% and perhaps 50% of the students are misplaced. (FU16, p. 6)

Mr. Merle explained that there were four students who were siblings in the same class and all were performing at the Grade 6 level; however, when Mr. Merle suggested that it would be more
appropriate for them to be enrolled in the Grade 7 course in another school, the parents insisted that they stay in the original placement.

All of these issues had a huge influence on the teacher’s intended and implemented curriculum. The students’ language and mathematics fluency resulted in on-the-spot changes to lessons or off-the-cuff lesson planning because student responses suggested a need for review, or in some cases, concept introduction (CO2). The students consistently needed more time for writing assignments than Mr. Merle anticipated (CO2, CO5, CO6), and he was required to spend considerable time defining not only mathematical terms but also English expressions (CO1, CO2, CO3, CO4, CO6). In every class, time management was an issue because the students’ literacy level generated many interruptions to the flow of Socratic instruction and to time on task during seatwork:

[w]e will have to move on eventually…. [I]n this ESL class you should have double the amount of time. I gave them 20 minutes to answer one question just like one we did two days ago but they got stumped because the wording of the problem was different. (FUI5, p. 4)

Planning Courses and Lessons with Reading Strategies

During the initial interview, Mr. Merle and I talked about his process for developing lessons and courses that included reading strategies in a variety of instructional activities. For this process, Mr. Merle relied heavily on the book *Teaching Reading in Mathematics* by Barton and Heidema (2002) (TRM) that provides in-depth discussions about the specific components that influence reading and comprehension (e.g., readers’ knowledge and skills, nature of the text, and teacher-student interaction); a research-based rationale for why we need to provide students with many opportunities to learn how to read specific mathematics text; and, outlines three practical reading strategies (illustrating each with appropriate and rich examples).
Mr. Merle planned his lessons with the three reading strategies, e.g., vocabulary development (i.e., Word Wall\(^5\), Frayer Model\(^6\), crossword puzzle, and oral explanation of the terms); reading supplementary text (i.e., children’s literature, teen fiction, and journal articles); and reflection (i.e., K-W-L chart), recommended by Barton and Heidema (2002). At the beginning of the course, he developed a planning template that outlined the units of the course and matched the best reading strategy to the content (see Appendix B). For the Grade 9 Academic ESL course that I observed, Mr. Merle developed long range plans for three major units: *Measurement and Geometry*, *Number Sense and Algebra*, and *Linear Relations* and then he made connections among the overall mathematics curriculum expectations to specific reading strategies, either vocabulary development, use of supplementary text, or reflection. Mr. Merle believed that his self-generated, long-range lesson planning template forced him to think purposefully and in advance about opportunities for implementing reading in his lessons:

> At the very beginning…you need to identify “Where are you going to use reading strategies?” and…to keep referring back to the template for your unit planning…and flag things as you think of them. And then eventually it just becomes more natural. You find yourself thinking, “Hey!” I should implement that [reading] strategy for that topic. As you become more and more familiar with the strategies then it’s easier to just pull one out of the air when you’re teaching a lesson that’s not working…maybe I can fix it or change it if I use such-and-such a reading strategy. (II, p. 17)

The self-generated long-range lesson planning template played another important role: “if [reading mathematics] is to be a major part of the program, then [the template] makes it obvious. For me, the template is a reminder that reading is not an add-on” (II, p. 12). In addition, this professional tool reminded Mr. Merle to look at the curriculum document from a reading perspective:

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5 World Wall is “a wall, chalkboard or bulletin board listing key words that will appear often in a new unit of study” (Ontario Ministry of Education and Training, 2003, p. 30).

6 The Frayer Model is an example of visual organizer “that helps students to understand key words and concepts” (Ontario Ministry of Education and Training, 2004, p. 34). The framework of the Frayer Model includes: the key word, the definition and characteristics of this word, examples of the key word, and non-examples of the key word (see Appendix E).
for example, if the curriculum expectation introduces a new key vocabulary word then I make a note to have a Word Wall up…. [When] we are working on a unit and there is a key word that students really need to know, we would use a Frayer Model to get the students to go in depth with [the definition of that word]. (II, p. 17)

When I asked Mr. Merle which of the three reading strategies he used most often, he replied that he used vocabulary development strategies most often followed by activities that used reading passages and least often, reflection (II, p. 14). Mr. Merle emphasised that teaching vocabulary was always a part of introducing new material and integrating vocabulary development strategies was the easiest of the strategies to do in every lesson and in every unit (II, p. 26).

At the beginning of the each unit, section, and chapter, Mr. Merle created a Word Wall that featured all of the new or important terms that the students would be required to know. During the unit he added vocabulary as necessary and when the unit finished he moved the Word Wall to the back of the classroom and prepared a new one for the next unit. The purpose of the Word Wall: “is that at the end of the course the key words that we used throughout the entire course will be recorded” (FUI2, p. 5).

Meanwhile, Mr. Merle stressed that he was struggling to find suggestions to enhance his use of the Word Wall in the research literature. Although he developed his own way of utilizing the word wall, he was less than satisfied with his efforts:

for the Word Wall they basically say you put the words on the wall, right, but then, the next question is “What do you do with these words?” So I am trying to make the most of the Word Wall on my own…there is nothing about it in the literature and I’d like to learn more or even learn if I’m using it correctly. (FUI2, p. 8)

Mr. Merle described the order of using different vocabulary development strategies (e.g., Word Wall, cross word puzzles, the Frayer Model): “we talk about the words to make sure we know how to pronounce them, spell them, and know what they mean and we are using the Word Wall. Then eventually we do a Frayer Model to bring everything together” (II, p. 26). In
Mr. Merle’s experience, the Frayer Model can be difficult for students, especially, when they try to complete the non-example box:

[it] is not always that easy to do. The first time around, it takes some help on the teacher’s part to get them to write what you expect…but it has to be in students’ own words. They always ask, “What do you mean by an example or a non-example?” When you work through some examples together, they eventually figure out what you want and they are successful at filling in the boxes. (FUI2, p. 7)

Mr. Merle believed that students’ facility with the vocabulary supported the learning process, especially during classroom discussions: “the teacher is speaking and the students are speaking and there is common understanding of the language that has been used” (II, p. 19). Without consistent vocabulary, Mr. Merle contended that there were more opportunities for misconception and confusion or both:

sometimes I can say a word for example, solution. You want kids to start thinking in terms of mathematics solution not in terms of chemistry solution. Sometimes the words…have different meanings in math and science, they have different meanings in English and everyday language. So you want kids to know that when they say something in math we are all talking about the same thing. (II, p. 19)

While using supplementary text, Mr. Merle noticed that the connections needed to be highly evident between the curriculum and the message in the book:

I cannot just pick up any story and read it to the class. It has to have something that directly relates to the curriculum. I have only a finite amount of time in class and that time must be well-spent class time. (II, p. 27)

Mr. Merle found that this restriction helped to create an overall balance in his program. However, while the Measurement and Geometry unit offered particularly rich connections to many titles from children’s literature that illuminated complex mathematics concepts in engaging ways, other units were limited by the availability of quality books and the nature of the content itself. For example, in the Algebra unit, Mr. Merle found that he did not have the time for literature-based activities because the content “is really heavy in vocabulary development. There is no getting around it. They need to know what things like polynomial,...coefficient, simplify, expand, and evaluate are and that takes time” (II, p. 17).
Mr. Merle’s approach to using supplementary text meant that he read passages aloud to students from a novel or newspaper article: a process that could take 10 minutes or more. The oral reading was followed by an exercise in which he asked the students to write a summary of what had been read. After that, students worked on assignments based on mathematics questions that emerged from the passage (II, p. 13). In reading the passage, Mr. Merle demonstrated how to read by using the title, printed in bold font words, pictures, and by posing questions (II, p. 13).

Based on his own prior experiences, Mr. Merle realized that in order to ensure students’ attention while he was reading, he needed to have a strategy that made them accountable for listening:

I learned from the time I read the *Greedy Triangle* by Marilyn Burns that I needed a way to make the kids focus. So I told them to write down where they heard about triangles, quadrilaterals, hexagons, or pentagons. It forced them not to day dream during the story. Then I had them write a couple of sentences to summarize the story and the mathematics involved in the plot. (II, p. 29)

Mr. Merle’s implementation of reflection strategies were actualized through expository writing and used of the K-L chart. He used the chart at the beginning of each unit or chapter as a pre-test, and at the end as a summative assessment. Mr. Merle sometimes used his adaptation of the K-W-L chart during an individual lesson: “When I use K-W-L [activity] in a lesson, I do not consider it to be “a reading strategy” [but] more an opportunity to reflect on… and take ownership for their own work” (II, p. 16).

With respect to developing the handouts for both children’s literature assignments and vocabulary development templates, Mr. Merle, repeatedly stressed that he relied on samples from professional books, but trusted only his self-developed materials:

I do not think that I have ever made my photocopies directly from a resource book…. I used samples from the Bay-Williams and Martinie’s MLG book to get me started and then referred to my grade 9 curriculum document. (II, p. 25)

As for newspaper or magazine articles, Mr. Merle had to create questions by himself because there were few templates to follow. Particularly helpful ideas, in Mr. Merle’s evaluation,
were from the Media Clips feature in the NTCM journal *Teaching Mathematics in the Middle School*. For vocabulary development strategies, Mr. Merle routinely adapted activities from different publications (e.g., *Think Literacy* or NTCM journals) by selecting those that he considered most appropriate for him based on his professional intuitions: “there are a lot of vocabulary strategies in the resource books. I just picked out the ones that I understood or that I thought would be really useful [in my practice]” (II, p. 15).

In Mr. Merle’s attempts to integrate reading strategies and reading-based activities, he invested enormous effort into developing student materials and carefully identifying appropriate materials for the Grade 9 Applied students. After successful implementation of these resources and strategies, Mr. Merle decided to continue to adapt and revise his already developed materials, and use these and other appropriate strategies with the students in the Grade 9 ESL Academic Mathematics course during the 2007-2008 school year: “most of the strategies that I was using…for the 9 Applied course…I hoped to recycle and revise for this year’s [Grade] 9 Academic course because [I thought] they were good thinking questions” (FUI2, p. 9).

**Description of Lessons that Integrated Reading Strategies**

This section presents the description of lessons that used the three different reading strategies, e.g., vocabulary development strategies, reading supplementary text, and reflection strategy that I observed in the Mr. Merle’s classroom. I detail six lessons, each of which presents one or some combination of these reading strategies. The presentation of each lesson begins with a description of the activities as they happened in the lesson (e.g., teacher’s performances, and students’ reactions) and concludes with a summary of the follow-up interview with Mr. Merle. In sum, I illustrate four lessons which related to the *Algebra Unit* and two lessons which were implemented during the *Measurement Unit*.

**Lesson 1: Scavenger hunt.** The first lesson that I observed was centred around a textbook scavenger hunt activity and the teacher’s oral explanation of mathematics terms. I
observed this lesson during the second week of the second semester: a point early in the course.

Mr. Merle opened the lesson by asking if anybody had experienced difficulties while completing the homework exercise. Several students said that they could not solve the problem: “You are given two points. Find two other points such that the four points form the vertices of a square.” In this problem, some students did not understand what was meant by the word *vertices*.

Mr. Merle turned to the class for an explanation of the term *vertex*. Some of the students were able to give an accurate definition. Next, Mr. Merle wrote these pairs of words on the blackboard: *vertex [...] vertices; boy [...] boys; and girl [...] girls*. He asked students to identify the difference between *girl* and *girls*, *boy* and *boys*. Most of the students were able to identify the fact that *girls* was the plural of *girl*. Mr. Merle explained that the same principle applied for *vertex* and *vertices*—the latter was the plural of the former. He also explained that the plural was not as obvious because the single, *vertex*, ended in an ‘x’ so the general rule of adding an ‘s’ did not apply. After this small activity, Mr. Merle directed students to page 22 [in their mathematics textbook *Principles of Mathematics 9* by Chris Dearling et al. (2006)] where *vertex* and *vertices* were written in the margin and highlighted. He emphasized that the fact that the words were highlighted meant that it was very important to know these words. After this students identified other highlighted words.

Next, Mr. Merle asked the students to raise their hands if they knew that there were answers to the textbook questions in a special section at the back of the textbook. Most of the students began talking to each other, asking one another if this was true. Most of the students were really surprised to learn about this feature of their textbook. One of the students sought confirmation from Mr. Merle that it was true that the answers to their homework problems were available for their use (CO1, p. 1). Mr. Merle said that it was important for them to know that they could use the solutions to check their work for correctness or for help. Mr. Merle said that it
could be very useful to know what other supportive resources could be found in a textbook, and then distributed a worksheet called the *Textbook Features Scavenger Hunt* (see Appendix F).

Students worked in pairs, sharing a textbook to find answers. When one of the students asked if this assignment would be marked, Mr. Merle answered that he was not going to mark this assignment because the main purpose of the exercise was to help them to become familiar with the textbook. During this activity, Mr. Merle circulated around the classroom providing individual assistance where necessary.

The most common questions that students asked Mr. Merle were about the meaning of the words used as headers within the textbook exercises themselves: *extend* and *practice*. Mr. Merle suggested that the students use their English/first language dictionary, first to find the meaning of the word and then to translate the words into their own language. When most of the students in the class had finished working through the questions on the assignment, he reviewed students’ answers in a whole class discussion format. He randomly asked students to read the questions, and then he asked for a volunteer to give the answer and explain why they chose this answer.

The most difficult task for the students was to distinguish between the headers in the exercises: *Practice, Connect and Apply*, and *Extend*. Mr. Merle explained that *practice* problems were the easiest mathematics problems in the chapter, and they were assigned early in the exercise. Mr. Merle explained that ‘connect and apply’ problems were assigned to help students to see why and where a formula or rule could be useful. As they learned more about a particular mathematical idea, said Mr. Merle, they would work on the ‘expand’ problems—challenging questions, often in the form of word problems that embedded the skills and knowledge that they learned and put them in a new context.

After the scavenger hunt exercise, Mr. Merle told students that they were going to prove the following statement: “The sum of any two consecutive whole numbers is an odd number”. He
wrote down the problem on the chalkboard, and underlined key words, e.g., sum, consecutive, whole number, and odd number, i.e., “The sum of any two consecutive whole numbers is an odd number.” He asked students to state definitions of the underlined terms in their own words. As students defined or provided examples to illustrate the terms Mr. Merle made some notes above the words, for example, for sum he wrote 4+5=9.

During the follow-up interview, Mr. Merle told me that although one goal of the lesson was to introduce students to their textbook at this early point in the course:

> [t]he goal of this lesson was to get them to be familiar with the textbook [that] we have been using [in this course]...this is the second week of the course and I knew some of the kids did not know [that] there were answers at the back of the [text]book…. I thought this would be an important activity because we are going to be using the textbook extensively in the course, (FUI1, p. 1)

the principal goal for the lesson was to introduce students to two mathematics processes: reasoning and proving.

Mr. Merle explained that he regularly used the scavenger hunt activity with students once per semester, usually at the beginning of the course (FUI, p. 1). This activity was adapted from the TRM book and it was the fourth time that he had used some version of it (FUI1, p. 2). He continuously modified the activity sheet after reflection on its use in the classroom:

> when I used this worksheet with my last 9 Applied class, we were using a different textbook…. I adjusted the worksheet to fit the structures and features of this new book by using key phrases from the table of contents and the chapter headers. (FUI1, pp. 2–3)

Mr. Merle also emphasized that he included many questions about chapter one; since the students had just finished that chapter and should have been familiar with its organization and structure:

> I deliberately included stuff that we have done before from chapter one. So, [I was] hoping that they would figure out [that]... ‘extend’ means the hardest question. The majority of the questions designed [on scavenger hunt were] to show that the same words will appear over and over again and that some sections of the book will be helpful no matter what chapter we are doing…but…I did pick chapter one for some questions specifically, because they had already done questions in that chapter. (FUI1, p. 4)
When I said that I had noticed that almost all students had difficulty answering questions about exercise headers, Mr. Merle replied that it was unusual to see these formal terms used as titles:

I was surprised to see those terms. Usually...the textbook uses letters: A, B, and C. Teachers and students expected that the hardest questions are in section C, the easiest are in A and the application questions are in B. That rule was familiar and made sense but...these terms [e.g., practice, connect and apply, and extend]...that was also new to me. (FUI1, p. 4)

In addition to letting students use their first language/English dictionaries during class and for all assessments, Mr. Merle also allowed the students to sit where they wanted so that they could sit with a peer who “could translate for them or [could] talk in their own language” (FUI1, p. 2). Mr. Merle also added that for ESL students he needed to pay close attention to key terms in the problems:

for these kids[ESL students], there is no assumption made that they know what a square is, because [English] language is not [their first language].... There are English words that they might not know.... They could be even thinking of an exponent...[or] they might be thinking differently in terms of what my interpretation of a square is and what their interpretation is. (FUI1, p. 3)

Since the scavenger hunt activity took longer than anticipated, Mr. Merle was forced to rush through the proof exercise. He believed that he had successfully introduced the students to the ‘big idea’ of the chapter by modelling behaviours that the students should adopt, i.e., underlining key words, defining key words, thinking of examples, paraphrasing the question (FUI1, p. 5). Mr. Merle reiterated his belief that the time spent on the textbook introduction activity would have long-lasting benefits for the students (FUI1, p. 6).

Lesson 2: The K-L chart. The second lesson that I observed was dedicated to the implementation of a reflection strategy known as the K-W-L chart. This lesson took place two days after the scavenger hunt activity. The first thing that the students did in the class was write a diagnostic test–The Diagnostic Mathematics Assessment for ESL Students: A Test Based on Selected Grade 8 Expectations (see Appendix G). When Mr. Merle told his students that they
would be writing a test, they were really disappointed because they had just had a test in their last mathematics class. Mr. Merle attempted to put the diagnostic test in context, explaining that after grading the previous day’s test he realized that some students appeared to be unfamiliar with some aspects of the curriculum from previous years, and so this objective diagnostic test was designed to help him to understand where there may be gaps in their understanding (CO2, p. 1). He further explained that the results from the test might be used to guide students towards a more appropriate mathematics course. Mr. Merle had allocated 25-30 minutes for the test; however, the test consumed 55 minutes of the 70 minute class period because the students required more time than expected.

During the administration of the test, many students asked questions, particularly about terminology. For example, one student asked for Mr. Merle’s input to understand what was meant by this question: “An outcome is a possible result of an experiment. List the possible outcomes of the following. A coin is tossed ...” Mr. Merle began by asking the student if he knew what an ‘outcome’ was. The student said that he did not. Then Mr. Merle posed a question based on a concrete situation: “if I dropped this pencil case on the floor, how many ways could the pencil case land?” (CO2, p. 1) When the student began explaining the possible variations of landing, Mr. Merle explained that those possible variations were called outcomes.

After the students submitted their completed test papers, Mr. Merle gave them a blank sheet of paper that had been folded in half. He drew a diagram of the paper on the chalkboard and explained that this paper had two parts. On one part he asked students to write the question: “What do I remember about Algebra?” and encouraged them to write down anything that they remembered about studying ‘algebra.’ On another part of the paper, he asked the students to write “What have I learned about Algebra?”, but he did not ask the students to answer this question. The students had 10 minutes to complete the task.
I noticed that the students were not writing anything on their papers. Then, one student spoke up and asked “Could I say that ‘algebra’ is mathematics?” Mr. Merle encouraged this idea and said that it was a very good start if you knew that algebra related to mathematics. When the students began to talk among themselves to come up with answers, Mr. Merle asked them to work individually so that he could get a better idea of each student’s background with ‘algebra’ to use as a starting point for the unit. The students spent a few minutes with their papers, and the class ended.

After the lesson, Mr. Merle and I had a follow-up interview. Mr. Merle suggested talking about the diagnostic test because he wanted to explain why he used this particular instrument. He pointed out the goal of the test in general:

[t]his diagnostic test was written for students who are ESL...[and they] have come to Ontario.... So this [diagnostic test] is on the Grade 8 mathematics curriculum in Ontario, and they [instructors] want to find out what the kids remember...[from] Grade 8 mathematics [curriculum] and then they will place you depending on how you do on this test. (FUI2, p. 1)

Mr. Merle noticed that the students were struggling with the mathematics terms in the questions: “the kids were asking things like ‘What is ‘area’?’, “What is ‘circumference’?” They do not know what those words mean [so] “How are they supposed to calculate what the ‘area’ or ‘circumference’ is?” (FUI2, p. 1). He cited another example “one kid did not even know what ‘radius’ is…. How is he supposed to calculated ‘circumference’ or ‘area’?” (FUI2, p. 1). He also mentioned that two students “did not know what a ‘rectangle’ was, they thought that it was ‘triangle.’ So they drew a triangle instead of [rectangle]...a rectangle has four sides [but] they drew three sides” (FUI2, p. 1). Mr. Merle believed that it was impossible to separate the students’ problems with mathematics from their language barriers:

I elaborated with the pencil case. [I asked the student:] “If you threw the pencil case what would happen?”... He said “it would land on the floor”...and [I asked him] “What [else could happen]?”...he said “It can land this way or it can land sideways.” So, he knew...what is going on there. Then we did it with the coin. [That is why, I think] it was the language [because] he did not know what was meant by the word ‘outcomes’...[t]he
diagnostic was not too wordy, it was just some of the terms that they [students] did not
understand. (FUI2, p. 1)

Mr. Merle noticed that even though he provided more time than originally planned for the
diagnostic test, a number of students submitted the test papers completely blank. This situation
convinced Mr. Merle that a number of the students (≈7) were misplaced in terms of the academic
level. He reflected:

the diagnostic test took some of them a long time and some of them left a lot
of...[sections] blank, so...they have deficiencies [not only] with the language but also the
math, because this course...9 ESL is designed for students that...[function] as the [Grade]
9 Academic Mathematics level but need support for the language...and that does not seem
to be the situation for half of the class, that for [these students]...it is the language and the
mathematics that [are problems]. (FUI2, pp. 1–2)

After our discussion about the diagnostic test, I asked Mr. Merle why he used only two
columns, K and L instead of the typical three K, W and L in the reflection chart:

[what] I found, when I did this K-W-L thing...the kids wrote down everything that they
remembered about algebra, but when they got to the middle column What do you want to
learn?, they left it blank because they did not know what they wanted to
learn...[Students] do not have a choice [and they might ask:] “So, you tell us...you teach
us what we learn, so we do not have a choice of what we learn.” So, they never really
knew what to write down there. So I just said: “Forget it.” We will just do What do you
know? and at the end of the unit we will do What have I learned? (FUI2, p. 3)

Mr. Merle mentioned that his reason for using this strategy was to get to know what
students remembered about algebra:

I have to get feedback because we are going to start the Algebra unit, and I want to see
what they remember about it. I will read it tonight and then keep it until the end of the
unit when I’ll bring it back so...they can write down what they learned from the unit.
(FUI2, p. 12)

Mr. Merle was disappointed to find that most of his students had left the paper blank.

This led him to wonder aloud:

[while they were doing the K column], I was kind of wondering if the kids even knew
what the term ‘algebra’ was.... Maybe it means something different in their language, I do
not know, because some of them left it blank.... They did not have much to say.... So
maybe they do not know what the word ‘algebra’ is, but if they have taken Grade 7-8
mathematics [courses] in Ontario they should have heard of the word ‘algebra’.... I can
understand if the kids come from another country they have never heard of the word
algebra, so that could be a problem. (FUI2, pp. 3–4)
I asked Mr. Merle how he classified the K-W-L activity, he answered that he considered that literacy, particularly, reading should be tied to assessment and writing because while students were doing K-L chart they would be evaluated on their use appropriate mathematics terminology:

\[\text{everything is intertwined here [in the K-L activity]}...\text{we are using this diagnostic, K, as an assessment of what they remember. But again the key word is algebra.}...\text{When I assess their work I am going to see if any of the mathematics terminology from the Algebra unit has been used. (FUI2, p. 4)}\]

**Lesson 3: Word Wall.** The third observed lesson took place one week after the previously observed lesson. This lesson was selected by Mr. Merle to illustrate an activity that he used to integrate a vocabulary development strategy: the Word Wall. Before the students came into the classroom, Mr. Merle taped several pieces of paper to the blackboard. On One was written the title *Word Wall #1* while the others displayed terms such as: ‘exponent’, ‘power’, ‘base’, ‘variable’, ‘algebraic expression’, ‘term’, ‘polynomial’, ‘degree of the term’, ‘degree of the polynomial,’ and ‘distributive property.’

At the beginning of the lesson, Mr. Merle said: “today we are going to go over a lot of vocabulary from this unit, because we need this vocabulary in order to understand each other and understand the mathematical problems” (CO3, p. 1). To introduce his students to the new vocabulary, Mr. Merle used coloured algebra tiles: red and blue. He asked students to record in their notebook that red tiles represented negative numbers and blue tiles represented positive numbers. Then Mr. Merle reminded students that in the previous lesson they used a square tile to represent $x^2$, a rectangular tile to represent $x$, and a small square tile to represent the number 1. On the overhead, he placed three blue squares, four red rectangles, and five small blue squares and then asked students to write down an expression that communicated what was being represented. After a few minutes, Mr. Merle wrote down the answer: $3x^2-4x+5$.

Mr. Merle began by asking the students what was meant by the letter ‘x’, and pointed toward the Word Wall. Then he asked what the ‘2’ represented in $x^2$. When the students
responded correctly with the words ‘variable’ and ‘power,’ Mr. Merle mentioned that these terms could be also found on the Word Wall. He explained that the term $x^2$ was spoken aloud as ‘$x$ to the power of 2’. He explained that $3x^2-4x+5$ was called an algebraic expression which consisted of terms separated by symbols that stood for addition and subtraction. Mr. Merle also explained the meaning of all components from the algebraic expression (e.g., variables, letters, numbers, and coefficients). He congratulated the students for learning four new mathematical terms, i.e., algebraic expression, term, and coefficient, and reminded them that they could be found on the Word Wall at any time for their reference.

Mr. Merle emphasized to his students that knowing vocabulary would help them to solve word problems from the textbook. Mr. Merle directed the students to the ‘practice’ questions in the textbook about algebraic expressions, and together they completed the exercises orally. This was followed by Mr. Merle developing other expressions with the algebra tiles and posing questions about each representation.

As soon as the students finished this exercise, Mr. Merle said: “I would like to give the algebraic expression a name” (CO3, p. 4). He pointed out that just as students had names, algebraic expressions also needed names. He wrote $2x$ and asked how many terms there were. The students answered ‘one.’ Mr. Merle mentioned that since this algebraic expression had one term it was called a monomial. Then he wrote down the next expression $4x^2-3$ and asked the same question “How many terms does this expression have?” The students replied, ‘two’. Mr. Merle pointed out that: “this expression has two terms. It is called a binomial, like bicycle” (CO3, p. 4). He reminded them to think of a bicycle and its two wheels whenever they saw the word binomial.

Next Mr. Merle put the expression $5x^3-3x+1$ on the board and asked “How many terms does this expression have?” The students replied, ‘three’. Mr. Merle asked “What name might you give to this algebraic expression now that you have seen how we named the first two?” Several students were able to reply ‘trinomial’. After that he drew a square around all of the
algebraic expressions on the black board and said that each was a member of the ‘polynomial’ family. At the end of the lesson, Mr. Merle reminded the students that there would be a quiz the next day on this new vocabulary.

During the follow-up interview, Mr. Merle was anxious to talk about his use of vocabulary development strategies:

[t]he lesson was not the most exiting lesson of the course, but it really lays the foundation for the rest of the course. [After this lesson] when I use a mathematical term...the students will be on the same wavelength as I am. [In another words] when I say a term, it will mean something to them, so that was the intent of the lesson...[the goal of the lesson] was to get at the vocabulary…. The literacy and mathematical goals were intertwined in this lesson. (FUI3, p. 1)

He emphasized that he could not have every lesson be so rich in terms of vocabulary development, “not all the lessons are going to be like that” (FUI3, p. 1).

Mr. Merle believed that the oral, whole group activity aimed at speaking the language of the unit using questions from the ‘practice’ exercises in textbook had enormous value:

it is important to show students lots of concrete examples because giving them the definition is one thing but I think that the examples in the book show them what coefficients and variables look like in different situations…. That exercise was about looking at the definitions through the lens of actual algebraic expression. (FUI3, pp. 2–3)

When I asked Mr. Merle “Is there a difference between conducting this type of lesson in an ESL classroom and a non-ESL classroom?” he answered that:

I think the lesson would go a bit faster with a non-ESL class.... I would still introduce the vocabulary words but I would expect it to go faster. For ESL students...there are English words that the kids might not know.... That means we have to take the time talk about the things that I would just assume that the non-ESL kids would know. For this class sometimes when we define the mathematical term or vocabulary we first need to learn the English word and the kids need to think about what it translates to in their own language. (FUI3, p. 3)

Using ‘bi-cycle’ as a comparison for ‘bi-nomial’ was one example of how Mr. Merle tried whenever possible to make comparisons between everyday language and mathematics, especially in terms of prefixes. He stressed that word origins could help students to remember the definition:

[comparing the prefixes is useful] because it will help them to distinguish between what a ‘mono-nomial’ is, ‘bi-nomial’ is, ‘tri-nomial’ is.... [Because] they can make a connection to
what they are familiar with... So I use the literacy connection that prefixes of the polynomial names have the following meanings: *mono-* means one, *bi-* means two, *tri-* means three. (FUI3, p. 4)

Mr. Merle’s idea to focus on the prefixes of the mathematics terms was taken from a professional article, *Focused strategies for middle-grades mathematics: Vocabulary development*, by Rena Rubenstien in *Mathematics Teaching in the Middle School* (2007).

*Lesson 4: Eighteen flavours.* On the day after I observed lesson three, I had the opportunity to observe a lesson that Mr. Merle selected because it included activities that demonstrated his efforts to integrate a literature-based activity as a strategy to enhance comprehension and motivation: the poem *Eighteen Flavors* by Shel Silverstein (1974) as well as another vocabulary development strategy: a crossword puzzle (see Appendix H).

At the start of the lesson, the students were given a quiz on the vocabulary from the previous day. The quiz was in the form of a crossword puzzle. After several minutes, Mr. Merle noticed that students did not know how to complete the puzzle, so he asked them to put down their pencils and drew their attention to the blackboard. Mr. Merle drew the schema of the puzzle and explained the meaning of the words ‘across’ and ‘down’ as well as the numbers in the grid.

Although the quiz was on the words that had been discussed repeatedly over the past two days, the students were experiencing difficulty with the task. To get them started, Mr. Merle read one question aloud: “3x+5 has how many terms” (CO4, p. 1). He asked the students what a ‘term’ was and drew the students’ attention to the word on the Word Wall by saying: “remember we learned this word” (CO4, p. 1). When students complained that they could not spell the words, Mr. Merle again directed their attention to the Word Wall. Some of the students were using the Word Wall before being reminded to do so. A few even walked over to the Word Wall with their paper, apparently to check the spelling of the word. The quiz, intended to take 10 minutes, required 30 minutes. For the students who finished the quiz early, Mr. Merle gave each a photocopy of the poem.
After the crossword puzzle assignment, Mr. Merle read the poem *Eighteen Flavors*. However, before starting reading the lines of the poem, he asked “What do you think the title means? What is meant by the expression ‘18 flavours’?” Some students responded that a flavour was something that was added for taste. Then he asked “What do you think this poem could be about?” Some of students replied that it could be about different tastes that we were eating.

Mr. Merle read the first two lines of the poem: “Eighteen luscious, scrumptious flavors—chocolate, lime and cherry.” He stopped and said that these lines consisted of two flavours: one of them was ‘chocolate’ and the other one was ‘lime and cherry.’ Then Mr. Merle read another line from the poem: “Coffee, pumpkin, fudge-banana, caramel cream and boysenberry.” He paused and asked the students what boysenberry was. When the students replied that did not know this flavour, Mr. Merle asked them to look this word up in their dictionary. The first student to answer explained that boysenberries tasted like raspberries or blackberries.

After this exchange, Mr. Merle returned to the poem, reading: “Rocky road and toasted almond, butterscotch, vanilla dip, butter-brickle, apple ripple.” He asked the students “Do you recognize some of these flavours?” One student said that ‘toasted almond’ might taste like toasted nuts. Another student said that ‘apple ripple’ was the same as apple juice but warmer. Mr. Merle kept reading: “Coconut and mocha chip, brandy peach and lemon custard.” Most students did not know the last flavour. He told them that a ‘custard’ was a dessert made from eggs and sugar. One student asked “What does ‘mocha chip’ mean?” Mr. Merle said that ‘mocha’ was a mix of coffee and chocolate and ‘chip’ meant pieces. When Mr. Merle finished reading the first stanza of the poem aloud, he then returned to the lines of the poem to count the number of different flavours, ending at eighteen.

Then Mr. Merle asked “What do you think all of these flavours are about?” One student said that the poem was about cakes, or smoothie drinks. Another student said that he thought that the poem was about flavours of ice-cream. Mr. Merle read the next line: “Each scoop lovely,
smooth and round”. He asked “What does ‘scoop’ mean?” and the students answered that a scoop was a spoon for ice-cream. The teacher agreed and said that probably all of these flavours were flavours for ice-cream. He read the last two lines from the poem aloud: “Tallest ice-cream cone in town. Lying there on the ground.” He asked “What do you think happened to the ice-cream?” The students agreed: “the ice-cream had fallen on the ground” (CO4, p. 2).

When Mr. Merle finished reading the poem, he said that there would be an assignment based on the poem. He continued: the first part of the assignment was to write one or two sentences about the poem and the second part of the assignment was to solve a mathematics problem which was related to this poem, i.e., to find the height of an ice cream cone that was 18 scoops high.

He told the class that the measurement of the height of a cone was approximately 20 cm, and the height for each scoop was about 10 cm. He drew a picture of the cone on the blackboard. He explained that if it was just a cone then the height would be 20 cm, if it was an ice-cream cone with one scoop then the height would be 30 cm, if it was a two-scoop cone then the height would be 40 cm, and so on. Mr. Merle asked the students to create and use a chart to find the height of an ice-cream with eighteen scoops (see Figure 1). Finally, Mr. Merle asked the students to write the algebraic expression for $x$, where $x$ was an unknown number of scoops.

*Figure 1*

*Table of Scoop Number versus Cone Height*

<table>
<thead>
<tr>
<th>Number of scoops</th>
<th>Height of the ice-cream cone</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>$x$</td>
<td>Expression</td>
</tr>
</tbody>
</table>
During the follow-up interview for this lesson, Mr. Merle and I first discussed the
crossword puzzle. He told me that because the previous lesson was dedicated to learning new
vocabulary he wanted to see if the students understood and could apply the mathematical
terminology. In the past, Mr. Merle said that he had used oral quizzes to assess student
knowledge of the terms but he found that oral activities were not as effective or as non-
threatening as the more game-like crossword puzzle task. In addition, he believed that the word
clues to the crossword puzzles encapsulated important aspects of the definitions and their
representations:

one way of doing it was...to ask them to just define the terms, but this was a more fun
way of doing. [In addition] if the kids did not know a word or term right away they could
wait until they had completed [most of the squares in] the puzzle because the completed
crossword squares give them letter clues for the other answers. Seeing the words in the
puzzle seems to trigger their memory. (FUI4, p. 2)

Mr. Merle also discussed why he encouraged the students to refer to the Word Wall
during assessments or assignments. His immediate answer was that he wanted to remind students
to use the Word Wall as a resource throughout the unit:

I introduced [the Word Wall] yesterday. I watched as they were doing the quiz because I
wanted to see if any of the students would actually refer to the Word Wall. It is up there
for them. A few of the students used it.... [T]he idea was...to make Word Wall helpful for
them, and to make using it become a routine. They need to know that the key words will
be always up there for all assessments and that they are welcome to use the Word Wall.
(FUI4, p. 1)

Mr. Merle was eager to share the kind of strategies he used during his reading of the
poem. He pointed out one feature of his questioning technique specifically:

[T]here were lots of words that...the students did not understand. When that happened I
tried to help them by posing questions “What do you do to deal with situations like
this—when you get stuck by a word?”…You heard me say to one student: “Check your
electronic dictionaries”. (FUI4, pp. 2–3)

Mr. Merle posited that he posed questions in the hope of encouraging his students to become
active readers:

[I am trying] to get them to be actively involved in their reading, [and] to figure out what
Eighteen Flavors is about. Because if we do that [posing questions about the title]
beforehand then they start to...think out loud: “What could the flavours be about?” as opposed to just reading it [this poem] passively. (FUI4, p. 3)

Mr. Merle pointed out that it was very important to make sure that the students understood each line from the poem in order to capture the main idea that would become the focus of the complementary mathematics task:

the key to me is seeing if the kids understand the poem…. [W]hen the poem said ‘in town lying there on the ground’, I asked the students “What happened?” and I was pleased to hear that some of the kids figured out that...the ice-cream fell off the cone because the 18 scoops made the ice-cream cone too tall. That is the main idea of the poem. It does not tell us directly,...they have to make that connection and it was nice to see that some of the students were able to do it. (FUI4, pp. 3–4)

Mr. Merle recognized that there were special challenges for ESL students to read this poem. The language and the nuance of the poem were especially difficult for this group of students because of their level of English proficiency. However, he was confident that after the read-aloud activity, most of the students understood the poem: “some of the students understood it right away and they shared it with the rest of the class.... So, the students who did not understand at the beginning, got it” (FUI4, p. 4). Mr. Merle also intended to use the students’ written summaries to assess the depth of their understanding (FUI4, p. 4).

Mr. Merle stressed that the goal for this lesson was to model reading strategies for the students. He stated that students needed the teachers’ direction when they first experienced activities such as this as much as they needed the support of working with a peer on the task:

[r]ight now, I am working on teacher intervention strategies. I am trying to model reading strategies... Once I have done enough modelling in class...I will get them to start doing it by reading in pairs but at first, I will list what I want them to do.... So, it might be [that] they take turns reading a paragraph...one person reads the paragraph and the other person summarizes what was read. They will talk about [the paragraph] and make sure they understand [it]. [Then] they go to the next paragraph, and look at the title [to see] if there are any pictures to illustrate the paragraph and if there are any key words they do not understand. I hope my example makes them ask themselves “What do I do about that?” So eventually in the end, they will do it by themselves hopefully. That is the long term goal. (FUI4, p. 4)

Mr. Merle told me that he adapted this activity from the MLG resource book: “I know it is not my own work. I did not come up with this great activity because I had never heard of the
poem” (FUI4, p. 4). When I asked Mr. Merle “Are you planning to mark this assignment?” he answered that he would mark the second question—the mathematics problem. He would use the students’ written summary only to provide descriptive feedback: “the first question did not really have any mathematics in it. It was just getting at whether or not they understand the poem” (FUI4, p. 5).

Nonetheless, Mr. Merle recognized that the first question could be an enormous challenge for at least half the class because of their background and language proficiency, given that they had to write a summary in their own words. In addition, he pointed out that: “they have never had an opportunity to write [for me] in [their own] words yet…. My goal is to just read it [the students’ summary] and just give them some constructive feedback” (FUI4, p. 5). He hoped that by giving students feedback on what they had written, he would help them to build their confidence about expressing their point of view:

The feedback is to help them to articulate. [I]f they did not get then I will just make a few points on it... The intent is really to see how they are writing which might be really bad at the beginning but then with enough exposure to this...they will get better. (FUI4, p. 6)

At the end of our conversation, Mr. Merle emphasized that another goal for using the poem was to show the connection between mathematics and real life:

[t]he poem was an application of what they learned by putting it [mathematics concepts] into a context. So the poem did not teach them any new mathematics but it did help them to make connections from mathematics to the outside world. We can take a situation and from it we can actually find the height of an unknown number of scoops. (FUI4, p. 7)

Lesson 5: Holes. This observed lesson (part of the Measurement and Geometry unit) was three weeks after observed Lesson 4. In this lesson, Mr. Merle read an excerpt from the novel, Holes by Louise Sachar (1998), and posed mathematics questions that emerged from key ideas within the text.

Although there was a considerable gap between observations, it was clear that Mr. Merle continued to make vocabulary contributions to the Word Wall. This resource had expanded significantly in my absence and now included terminology from both the Equations and
Measurement chapters. The following mathematics terms were included in two new columns on the Word Wall: 1) double, increase, decrease, more than, less than, and, equal; 2) hypotenuse, Pythagorean theorem, diagonal, perimeter, circumference, area, composite figure, volume, surface area, radius, diameter, parallelogram, trapezoid, prism, pyramid, cylinder, and cone.

As in the previously observed lesson, the first activity for the students was a quiz on calculating the volume of 3-dimensional solids. Mr. Merle distributed two photocopied sheets to the students: the quiz and a formula sheet which showed diagrams of 3-dimensional solids and formulae for finding volume and surface area. He emphasized that students could use the formula sheet during the quiz and keep it in their notebooks as a reference throughout the unit.

When the students completed the quiz, Mr. Merle explained the agenda for the rest of the class: he was going to read from the book *Holes* and then there would be an assignment based on what he had read. He held up the book cover for the students to see and mentioned that some of them might have seen it before because he knew it was used in some Language programs in earlier grades. However, no one in the class was familiar with the novel. Mr. Merle’s first question was “What do you see on the cover?” The students answered ‘sand’ and ‘holes.’ Mr. Merle told the students that there were no pictures in this book; therefore, they would have to rely on their own listening skills and imagination to follow the story. He began reading aloud page 2-3, taking care to enunciate clearly and use exaggerated intonations. After a brief pause, Mr. Merle continued reading aloud, moving on to page 5. After a final pause, he turned to pages 26-27 and read a concluding passage.

While Mr. Merle was reading the story, the students were listening very attentively. Even when he was circulating around the classroom, the students turned their heads to follow him. As soon as Mr. Merle finished reading, he asked the students to write down a few sentences that described in their own words what the story was about. He gave them about seven minutes for this purpose, and then he asked the students to look at the worksheet (see Appendix I). Mr. Merle
reviewed the worksheet with students and provided clarification for the each of the sentences on the worksheet.

For example, he explained to students why some of the text was italicized or in a bold font. In addition, he directed their attention to the formulae provided on the page. As had been his practice before, Mr. Merle assured the students that he would not grade the written summary of the story but would provide a mark for their solutions to the mathematics problems assigned because they were on concepts that had been taught and practiced in class.

Mr. Merle referred to the worksheet, reminding the students that italicized passages were direct quotes from the book. He read aloud a passage that he had provided for the students on the worksheet:

The shovels were kept in a shed near the showers. They all looked the same to Stanley, although X-Ray had his own special shovel, which no one else was allowed to use. X-Ray claimed it was shorter than the others, but if it was, it was only by a fraction of an inch. The shovels were five feet long, from the tip of the steel blade to the end of the wooden shaft. Stanley’s hole would have to be as deep as his shovel, and he would have to be able to lay the shovel flat across the bottom in any direction. That was why X-Ray wanted the shortest shovel. (Sachs, 1998, p. 27)

After reading this passage Mr. Merle asked the class to explain the scenario of the story. One of the students volunteered to explain, saying that it was about a boy who was being punished by having to dig holes. Mr. Merle asked “What kind of hole should he make?” The students had no response to this question, so Mr. Merle rephrased: “if I had the five foot shovel “How deep does the hole have to be?” (CO5, p. 1). One of the students answered ‘five feet.’

Mr. Merle continued “What about the width of the hole?” One girl answered ‘five feet.’ Mr. Merle checked “Do you understand now?” and added:

I need to make a hole and I have this shovel [he started drawing a sketch of the shovel on the blackboard and pointing to the diagram] I need to fit the shovel in so that its fits inside the depth and width of the hole. (CO5, p. 2)

Mr. Merle asked the students what would happen if another boy had a shovel that was one inch shorter than other the first boy’s shovel: “What can you say about this boy’s hole?” One student
replied that it would be one inch shorter in the width and one inch shorter in the depth. He pointed out that he had done the first step in the second problem for them by computing the length of X-Ray’s shovel to be 4.96 feet (CO5, p. 3).

Mr. Merle moved on to another question, reading aloud: “Question C: compare the areas of the circles. Is having a slightly shorter shovel significant in the amount of dirt removed?” (CO5, p. 3). To get the students started, he asked “What does ‘compare’ mean?” The students were hesitant in answering so Mr. Merle answered his own question: “we use ‘compare’ when you need to look at two things and find the difference” (CO5, p. 3). He also explained that the first step was for the students to calculate the area of the circle made by each shovel and the difference between the two to find who of the boys had to do more work. After that Mr. Merle moved to another question from the worksheet. These questions were about the fact that the hole was in the shape of a particular 3-dimensional solid and that they needed to decide what kind of solid a hole most closely resembled. As for questions ‘B’ and ‘C,’ Mr. Merle invited the students to refer to the formulae that he had provided on the worksheet and on their the formula sheet.

The first topic of conversation in the follow-up interview about the Holes lesson was the World Wall. When I asked Mr. Merle about the new words on the Word Wall, he explained that these words were for the Measurement unit. Mr. Merle regretted that he could not post the words for the unit at the beginning of the unit. This missed opportunity led him to reflect:

In the ideal world, the Word Wall goes at the beginning of the unit but...[for] the Measurement [unit], [it] did not go at the beginning it went up [in the middle].... [T]hat is really bad, it should go up...before the unit started. But again this is the first time I have taught 9 ESL Academic. So, next year when I will teach the course again, I will have all the words...[and the Word Wall] will go up at the beginning. (FUI5, p. 1)

Mr. Merle described his process for deciding which words should be posted on the Word Wall:

I skinned the textbook, skinned the curriculum document, and I thought about which key words needed to be there. Some of the key words...like ‘perimeter’ and ‘area’ were up there as well.... In a regular 9 Academic class [word like] ‘area’ probably would not
go up because that is not really a Grade 9 word [term], but for these kids [ESL students] these words had to go up. Basically, all the key words went up. (FUI5, p. 1)

I noticed that Mr. Merle had included a number of phrases on the Word Wall, for example, ‘more than’ and ‘less than’. He stated that these phrases were part of the Equations unit. During that unit, he found that the students were struggling with these conjunctions while solving mathematics problems. Since these were expressions that the students would encounter over the long term throughout their mathematics courses, Mr. Merle wanted to reinforce their meaning:

There are some word problems, that we did, when we have to write an algebraic equation. The kids had to solve problems [with] ‘more than’ and ‘less than.’ I was trying to help them with what that meant... So, we are going down to that level. The word wall had to have very basic words because some of them [the students] do not even know basic terms...even today’s lesson...that Holes’s assignment...[the words] like ‘fewer than’… a couple of kids still did not know what that meant. (FUI5, pp. 1–2)

Mr. Merle added that he was surprised that students did not know these words, but he explained that he was still trying to adhere to the curriculum expectations and assessment standards for this course and so he continued to edit the Word Wall to reflect the students’ needs. “it surprises me that the kids did not know that, but it is the first time I am teaching the course and I am just basically plugging...my way through.... I am trying to...keep them [ESL students] going” (FUI5, p. 2).

Our conversation turned next to his reflections about the activity based on the novel Holes. Mr. Merle stated again that the idea of Holes and the worksheet he used originated in the MLG book which included explicit details right down to the concrete suggestions for how to use the book:

it says here ‘read chapters one and two, and then read the beginning of the chapter seven.’ So I did exactly that…. [In addition] they gave an outline of where the mathematics could be. I took that and made it into a worksheet. (FUI5, p. 3)

His worksheet reflected that: “chapter one described the summer camp and why the boys from the summer camp needed to dig holes while chapter seven specifically zoomed in on the possible mathematics questions” (FUI5, p. 5).
Mr. Merle said that the book *Holes* provided a rich opportunity for the students to apply the concepts that they had just learned:

[the goal of this assignment was] to make connections and to apply what they learned… [For example] some of them [the mathematics questions on the worksheet] are more application and some of them are problem solving, [e.g.] the last question “*How much would Lester X-Ray dig in 6 months?*” is more of a thinking question…. We are not learning any new math but we are applying the math that we have learned by putting it into a real life situation, into a context. (FUI5, p. 3)

Mr. Merle was disappointed that these students did not have the opportunity to read this novel as a part of their elementary school Language Arts program. The novel *Holes* is a recommended program book for Grade 6. In previous years, when he used this activity, e.g., with the Grade 9 Applied course in 2006-2007, students had been familiar with the scenario of the novel. According to Mr. Merle, this meant that:

his previous students saw the activity through a different lens. You read it in the Language Arts [course and] now you look at it from a mathematical lens or from a mathematical perspective…. [We can] see how we could use [mathematics and]…see where the math is in that [novel]. (FUI5, p. 4)

Still, Mr. Merle contended that he liked this particular activity because it focused simultaneously on literacy and practical application questions. Reflecting on his previous experience, Mr. Merle claimed that Grade 9 Applied students did not have any difficulties in solving the mathematics problems from the exercise. However, he found that his ESL students were struggling:

[i]t should not have been difficult [in terms of the level of difficulty of the mathematics problems] but for this group it is reading. If this was a regular 9 Academic class this would be an easy assignment…. I get them to communicate in writing how they compared the areas and compared the volumes…. For these kids it [the assignment] was not easy, because they have the language that they have to contend with. But the math is easy. (FUI5, p. 6)

Mr. Merle attributed the students’ difficulty in summarizing the novel to the fact that he read chapter one and then he skipped several chapters, finishing off by reading chapter seven. His second concern was that the students would write about *scorpions* and *rattlesnakes* in their
summaries instead of talking about the summer camp, why the boys were required to dig holes and what the consequence of shovel size was, i.e., the more mathematical issues in the novel.

Mr. Merle mentioned that he developed his *Holes* worksheet to include explicit scaffolds because it was originally intended to be used with Grade 9 Applied students who were known to have documented difficulties with communication. He believed that because of the efforts he made to develop this worksheet and the nature of its intended audience, that it would be well suited for ESL students who had problems with the English language (FUI5, p. 3). However, the supports were not sufficient and the ESL students required additional accommodations from the teacher. For example, a number of students had difficulty with the word ‘significant’: “the word *significant* was a big issue for them…the math was not an issue for the students. It was the language; that is why, [I was] trying to help them understand the language” (FUI5, p. 7).

When I asked Mr. Merle “*Why did you read the story aloud? Why did you not ask the students to read aloud?*” he answered that he was acting on suggestions from the experts in the MLG resource book. While Mr. Merle agreed that he could have prepared a photocopy to give to selected students to read aloud, he was unsure about the students’ level of comfort in oral reading: “the end-all goal is to have the kids read on their own, but we are not going to get there with this group. Maybe if I teach them the Grade 10 ESL” (FUI5, p. 8). His goal in teaching a Grade 10 ESL mathematics course would be to contain the focus on reading strategies. Maybe over two courses with such activities and him as a teacher, the students would be more comfortable and more prepared to read aloud: “we can continue on [reading strategies]. It will be more of a [classroom] routine” (FUI5, p. 8).

Mr. Merle’s main “goal [for] today was to assess them [students] on the volume of 3-dimensional solids” (FUI5, p. 9). His secondary goal was rooted in literacy:

one literacy goal would be listening which was important…and it was also reading as well because…after they listened to what I said, they had to read the quotes and the questions [from the handouts]…. And [there was] a bit of writing…when they had to explain their steps for comparing the areas [and volume]. (FUI5, p. 9)
Lesson 6: The village of round and square houses. The last lesson that I observed included both reading supplementary text and vocabulary development. The lesson centred on a children book *The Village of Round and Square Houses* by Ann Grifalconi (1986) and a crossword puzzle based on the *Measurement Unit*. I observed this lesson one week after observed lesson 5 (*Holes*), at the approximate mid-point of the course. This lesson began with a crossword puzzle assignment (see Appendix J), during which Mr. Merle allowed students to work collaboratively. As a result, most of the students gathered into small groups of between two and four. The students worked together, using their textbook and referring to the Word Wall. I noted that one group of girls was speaking in Chinese for the full 20 minutes that the teacher allowed for the assignment.

As usual, Mr. Merle circulated around the classroom as the students worked. When he noticed that most of the students had finished their work, he reviewed the answers in a full-class format. The students had some difficulties with several clues. One problematic clue was: ‘the amount of material in a 3-dimensional solid.’ Mr. Merle prompted students responses with other questions: “if we wanted to paint this classroom what measurement do we need to find?” (CO6, p. 1). When the students remained unresponsive, he provided an explicit hint: “[to paint the room,] first we would have to find the **surface area** but if we wanted to fill this room with the water we would have to find the **volume** of this room” (CO6, p. 1). Another difficult question for students was: ‘one third of the volume of a rectangular prism is the volume of what 3-dimensional solid.’ Mr. Merle was trying to paraphrase and to give another example: “if you take one third of the rectangular prism “What shape do you have?” Now think about what would happen if you had a cylinder and took one third of it: “What kind of 3-dimensional solid is that?” (CO6, p. 2).

After the crossword activity, Mr. Merle read aloud from the book *The Village of Round and Square Houses* by Ann Grifalconi (1986). Before he began reading, he asked the students “*What is meant by the word ‘village’?*” One of the students said that a village was a small town.
where poor people lived. Mr. Merle corrected the answer, and clarified that although the word 
village meant ‘small town’ the word village had nothing to do with the amount of money the 
people who lived there earned. He continued to introduce the book by telling the students that the 
author had based the story he was about to read on a true story from Africa. He showed students 
the cover art from the book which depicted the village (see Appendix K). Mr. Merle pointed to 
the artwork, asking the students to take note of the ‘square’ and ‘round’ houses. To link the cover 
illustration to the current topic of study, Mr. Merle asked the students to think about what 3-
dimensional solids the round and square houses referred to.

Before reading the book, Mr. Merle stressed once again that they should listen carefully 
in order to write a summary. He started:

It was not until I was almost full-grown and left my village that I found our village was 
like no other. For the men live in square houses, and the women, in round ones! To me, 
this seemed the natural order of things. “But what is it like?” you ask. I will tell you how 
it was–and is–for me. (Grifalconi, 1986, p. 3)

Mr. Merle paused to show the students the pictures of the houses. He carefully pointed to the 
square house and asked who lived there. Next, he did the same thing for the round house. Then he 
continued reading the story:

I grew up on my grandmother’s farm in the village of Tos that lies at the foot of Naka 
Mountain in the Bameni hills of West Africa. We planted yams and corn and tobacco and 
the finest coffee grown in the Cameroons. Our village was always happy and peaceful – a 
good place for boys and girls to grow up. (Grifalconi, 1986, p. 4)

Mr. Merle told the class that he would skip several pages, but before he continued reading 
aloud, he briefly summarized the pages he omitted: the village was situated in the middle of 
Africa and had a tradition that women lived in round houses and men lived in square houses. 
Mr. Merle prefaced his reading by explaining that the next excerpt was about the author’s 
grandmother and he showed the students the grandmother’s picture from the book. He noted, 
aloud, that the grandmother had recounted the story to her granddaughter who eventually grew up 
and wrote this book. He started reading: “In the days of long, long ago, the people of this village
lived in houses of any sort, either square or round it did not matter” (Grifalconi, 1986, p. 15).

Mr. Merle stopped and directed students’ attention to the fact that a long, long time ago people (both men and women) lived in both square and round houses, but after a time, the men and women were separated, one gender living in square houses, and one in round. After this interjection, he started reading aloud again:

Then one peaceful night before anyone alive remembers, Old Naka began to groan and rumble and awoke from a long sleep! The village were frightened and ran out of their houses and hid in the bushes at the foot of the mountain. (p. 15)

He stopped reading and asked the students “Who is ‘Old Naka’?” The students were struggling to find an answer until one of the students suggested that ‘Old Naka’ could be a storm. Mr. Merle agreed that ‘storm’ was one possibility, then pushed for other possibilities. One of the students eventually suggested that ‘Old Naka’ could be a volcano. Mr. Merle supported his idea and continued to read the novel: “A great wind came up and the ancestor spirits in the trees cried out to warn them. Even the rock began to tremble!” (Grifalconi, 1986, p. 16). Mr. Merle paused again and asked “What does tremble mean?” The students were arguing among themselves and then one student shouted that ‘tremble’ meant shaking. At this point, Mr. Merle asked “Could somebody tell me what happened in the village?” Most of the students agreed that the volcano, Naka, erupted. Mr. Merle agreed and moved on to the next passage, reading:

Suddenly, the black night was split open like a coconut! And a great white burst of light rose like the sun! Then the voice of our mother Naka thundered out over all: BOOM! BA-BOOM! BA-BOOM! And the people cried out to Naka, and prayed where they were lying down, hands pressing the earth, asking “What have we done to so anger you?” (pp. 16–17)

Mr. Merle paused again and paraphrased: “the people from the village understood that the volcano erupted but they could not understand what they did to make Naka so angry” (CO6, p. 3). One of the students said that when Naka erupted, it would make the village shake really hard and destroy the houses. Mr. Merle said that his suggestion might be correct and then proceeded to read aloud again: “All through the night Old Naka spoke to them shouting her anger to the skies
as red rivers of lava flowed down her sides” (Grifalconi, 1986, p. 18). Mr. Merle stopped again and asked “Could somebody explain what happened and what does ‘red river’ mean?” The students replied that the phrase ‘red river’ referred to the red-hot lava that shot from the volcano as it erupted. Satisfied with this response, Mr. Merle continued reading: “The morning sun rose but no one could see him. The anger of Naka was too great and ashes and smoke filled the air. Finally–no one remembers when–Naka spoke no more…” (pp. 18–19) Mr. Merle turned from the book to the class once more and asked the students to look at the pictures on pages 18-19 which portrayed pictures of the volcano, Naka, and lava cascading to the ground below. He returned to the book, reading: “Slowly–carefully–the people lifted their heads and looked about: everything was covered with ashes–even themselves!” (p. 20).

One of the students asked if everybody died and Mr. Merle said that he did not know. They would have to finish reading the book to answer that question. So he continued: “Everyone looked like a gray ghost–no one knew who stood next to them or who came behind... so they stood there–trembling with fear–but grateful to be alive: Naka had spared them!” (Grifalconi, 1986, p. 21). The same student interrupted him once again, expressing concern that everyone had died because of the volcanic eruption. Mr. Merle reassured him by saying that no one died, and to assuage his concerns, showed him the pictures on pages 20-21 as proof. After this episode, Mr. Merle returned to the book, reading: “Still covered with ashes–the men, women, and children faced the mountain together and went back to claim their homes” (p. 22).

Mr. Merle stopped again to make a quick summary: people from the village were alive and now they were returning to find their homes. Mr. Merle emphasized that the village people were covered by dust and grime from Naka’s smoke and ash. When one of the students asked if the smoke and ash would change the people’s skin colour permanently, the teacher answered, ‘no.’ Another student was trying to support Mr. Merle’s answer turned to the concerned student, saying that although the people would be covered in dust and ash from the volcano, the ash would
sit on the surface and would not change their skin colour. Mr. Merle agreed with this student’s explanation and kept reading: “But when they came to the burned-out village, only two houses were left standing: one square, and one round!” (Grifalconi, 1986, p. 23).

Mr. Merle asked the students “What happened in the village?” One of the students explained that Naka destroyed everything except one round and one square house. Mr. Merle asked “What else did Naka leave unhurt?” (CO6, p. 3) The students replied that Naka also left the village people alive. Although the students wanted to continue discussing what happened in the village, Mr. Merle interrupted them by saying that they could find out what happened if they gave him a chance to continue reading: “The people saw that only these two houses had been spared by Naka and they wondered to themselves: ‘Why these? Was it a sign?’” (Grifalconi, 1986, p. 24).

Mr. Merle asked why people from the village posed these question: “What does this mean—’Why these? Was it a sign?’” One of the students said that maybe they were wondering why Naka did not kill everyone and why Naka left just two houses.

Mr. Merle reminded students that all people were covered by dust and it was hard to distinguish between men and women. He kept reading:

But the village chief had no time for such questions—and he called them together: ‘We must begin to rebuild our village now!’ He pointed to the ash-covered people: You! Tall gray things! You go live in the square house! And you! Round gray things—go live in the round house! And you small gray stones go out to the fields so we can plant our crops again. (Grifalconi, 1986, pp. 25–26)

Mr. Merle then asked students, “Why did he call out to ‘tall gray things’ and ‘round gray things’?” Some students guessed that the tall gray things were men and round gray things were women. One student interrupted “Why did the Chief send them to the houses?” To this question, Mr. Merle replied that probably the Chief felt that they should focus on re-building the village because Naka’s eruption had destroyed everything. To support his response, Mr. Merle read:

And so it was done. The women lived in the round house with the children and the women talked and laughed—preparing food for everyone. The men stayed in the square house and told each other tall stories and planted yams and corn each day, in the new, rich soil. (pp. 27–28)
Mr. Merle showed his students the illustrations from the book and commented that the women were cooking while the men were working in the fields. One of the students asked: “What did they grow? What does ‘yams’ mean?” One of her peers said something to her in her first language and it seemed the girl understood since she nodded her head affirmatively. Mr. Merle kept reading:

And the children made a game out of clearing the field of small, gray stones and went swimming and fishing in the long afternoons… And no one forgot to thank Naka for sparing their lives and giving them back such fine crops from her good earth. (Grifalconi, 1986, p. 29)

One student was puzzled: “so Naka gave them back their houses?” (CO6, p. 4) and Mr. Merle said that Naka saved just two houses and the other houses were built by the village people themselves. As soon as Mr. Merle finished reading one of the students asked: “Has Naka spoken again?” (CO6, p. 4), Mr. Merle answered that he did not know since this story was over and maybe another book would tell that story.

At this point, Mr. Merle asked the students to write down several sentences about the story. As they worked on their summaries, Mr. Merle circulated around the class, reminding students to write something about the mathematics connections (i.e., round and square houses) not just about volcanoes or dust.

When the students finished writing their individual summaries of the story, Mr. Merle directed their attention to the worksheet (see Appendix L). He read the first question: “Which house do you think will require the least amount of materials to build? Give a reason to explain your choice” (CO6, p. 3) and said that they should estimate the number of bricks required. Next, Mr. Merle read the third question and asked students to refer to the figure shown on the worksheet (i.e., a schema of the square and round houses):

What is the shape of the 3-dimensional solid for the roof of the square house? What is the shape of the 3-dimensional solid for the walls in the square house? How would you calculate the surface area of the square house? (CO6, p. 3)
Mr. Merle asked them to recall what was meant by the phrase ‘surface area’ and then he reminded students that when they painted a house they did not need to paint the floor. After that he pointed out that in order to find the surface area of a square house they should think about how many sides they needed to build the house (the same question was in the worksheet labelled as a hint). Most of the students began to solve the problems after Mr. Merle’s lesson debrief; however a few students still seemed confused. Mr. Merle gave these students individual attention by asking questions: “What is the shape of the wall?” and “What is the shape of the roof?” He referred these students to the pictures on the worksheet.

During our follow-up interview Mr. Merle and I talked about crossword puzzle and the activity from the children’s book. My first questions were related to the implementation of the crossword puzzle. Mr. Merle said that he developed this puzzle with questions that included the definitions of the mathematical terms from Measurement unit and application of the formulae for 3-dimensional solids (FUI6, p. 1). Mr. Merle considered that this crossword puzzle was an opportunity to build student confidence:

I did not want them to work alone. I wanted them to have the opportunity to work with other students...and if they needed to refer to the textbook or whatever, they could..... I wanted this [crossword puzzle assignment] to be more of an opportunity for them to consolidate what they were learning and make them feel good about what they knew. (FUI6, p. 2)

Next, we talked about reading the book, The Village of Round and Square Houses. Mr. Merle stated that the main goal of reading this story and solving the related mathematics problems was to make a connection between 3-D formulae and the real world:

[t]he purpose was to make a connection to the mathematics content which was surface area.... It is a real story...[about] a village in Africa that is made up of square and round houses. It is a true story. I wanted them to calculate the surface area of each of the houses. So, it was an application of the math that they had learned. (FUI6, p. 2)

Mr. Merle believed that the questions that were posed based on this story were good thinking problems:
We are not just calculating the surface area of one solid... [W]e have combinations of two solids. So, that is a good thinking question. I think...it really helps them not only to consolidate [their knowledge about 3-dimensional solids] but also to dig a little deeper into mathematics concepts. (FUI6, p. 2)

Mr. Merle pointed out that this activity took longer that he predicted because he was trying to make students think aloud:

[i]t took a little bit longer than I anticipated because.... I was trying to get across the point of story and to make sure that they understood it. That is why I was asking some questions like: “What does this [word] mean?”…and we were thinking aloud together as a class.... [S]ome of the words [from this story] were difficult [to understand], so I had to make sure that they understood what the words meant, for example, Naka, was one of the words. (FUI6, p. 3)

Mr. Merle thought that showing students pictures from the book helped them to understand what happened in the village:

[I] showed them [the students] the pictures. One of them was a picture of the volcano and the lava. I was trying to get them to understand that a volcano erupted. I thought that if I just read the story to them and they did not see the pictures then they would not have gotten a sense of what was going on in the book but they should. (FUI6, p. 3)

Mr. Merle stated that he did not read the entire book, instead focusing on the main ideas in the story, i.e., there was a village made up of square and round houses, and men lived in the square houses and women lived in the round houses, and it was a catastrophe that left only two kinds of houses standing (FUI6, p. 3).

Mr. Merle took the idea of reading using this particular story from the MLG book; however, he simplified the suggested mathematics questions by changing the dimensions of the square house because he was not sure that the students would be able to solve the original problem:

I simplified the house where the men lived in... because it is supposed to be a 1 foot gap [see Appendix L] or something... dimensions of the base here is 13. This is supposed to be 11... a triangular prism. But I just kept it at 13 just for simplicity’s sake. I just tried to make it doable for them. (FUI6, p. 4)

On reflection, Mr. Merle thought that students understood The Village of Round and Square Houses better than Holes: “I think this [assignment] was a little bit more successful in
terms of their understanding what the story was about as opposed to the *Holes* book and assignment” (FUI6, p. 3). Even after three months, Mr. Merle noticed that the ESL students in the class were still struggling with writing a summary of the story. He attributed this to his belief that they needed more time to learn how to write because of their level of language proficiency. He anticipated that students would show improvement by the end of the semester:

> It is going to take a lot of time. Over time it [their writing] will improve as they continue to write but from the last unit to now...it is hard for them to improve that quickly…. I think the comparison between now and the end of the semester would be a better comparison. I think that it will grow a bit. (FUI6, p. 5)

He mentioned that for most of the students the challenge was to focus on the mathematics embedded in the plot rather than on the explicit story lines:

> I was trying to prod them. When you tell me the summary of the book you do not just talk about the lava and everything, and how the village was destroyed because...that is not the key jist of it [the story]. The key jist of it is...[that] here are two types of houses, where one gender lives in one [house] and the other gender lives in the other. So, I wanted to make sure that they have gotten that, because that is really the key point of the book. (FUI6, p. 4)

Mr. Merle admitted that this was the first time that he had included this book and the supplementary assignment in his program. He explained that when he incorporated reading in his Grade 9 Applied Mathematics course he could not use it because according to the provincial curriculum policy document, this topic was not included; however, since surface area was a required part of the curriculum in a Grade 9 Academic course it seemed a natural opportunity for Mr. Merle to use this assignment (FUI6, p. 5).

When I asked Mr. Merle “*What was your goal for this lesson?*” he answered that this lesson represented a powerful summary for the unit:

> [t]he goal of the lesson was to dig deeper into the unit. So everything has been learned and yesterday’s [lesson] was a review class. [T]oday’s lesson was to dig deeper and to look at the concepts a little bit more....So, again, [we were] looking at the vocabulary [in order to] make sure that they knew the vocabulary.... [That is why, we] stepped back and reflected on the key words, to make sure they knew that. [T]hen this story was an application of what we did. It helped us to connect what we learned and to put it into an application problem or a thinking/problem solving-type scenario. (FUI6, pp. 5–6)
At the end of our interview, Mr. Merle talked about the problems that students faced while completing this assignment and during the course overall. He was convinced that the students’ performances suggested that they were struggling with mathematics more than with the language. For example, during this assignment he noticed that some students did not apply the formula for surface area when it was required. Instead, they used the formula for volume. It should be noted that most of the students did not answer any questions from the worksheet. However, he stated that according to the expectations for a Grade 9 Academic Mathematics course the mathematics problems should have been doable:

I gave them formula sheets...besides [these formulas were] on the [Village of Round and Square Houses’s] worksheet. So they did not even have to pick out the formula…they just left it [the worksheet] blank…. Some of the students were writing volume formulas [instead of the surface area].... The formulas were given to them and all they had to do to substitute values in and they still could not do it. (FUI6, p. 7)

Furthermore, Mr. Merle stressed that it took more time for this group of students to complete quizzes or assignments, e.g., The Village of Round and Square Houses’s assignment took 35 minutes instead of the anticipated 15, and still some students submitted blank papers:

you can give them [students] two hours and they will still sit there. I am not talking about all of them…. If there is a quiz and I give them 20 minutes to solve one equation….they will take 20 minutes to do it and then when you mark it, basically there is nothing there that is right...they do not get it because they do not understand. (FUI6, p. 8)

Mr. Merle believed that his students’ content gaps were the reason that he was behind schedule: “[I am] running out of time again. I mismanaged the time...that seems to happen, I think it will take this amount of time and then the reality is, it takes double the amount of time” (FUI6, p. 8).

This chapter presented Mr. Merle’s rationale for teaching students reading strategies in the mathematics classroom and described his observed practice over the Grade 9 ESL Academic course during the second semester of the 2007-2008 year. The data were analyzed and collapsed into three themes. The results of this analysis are discussed in the following chapter of this thesis.
CHAPTER FIVE: DISCUSSION OF THEMES THAT EMERGED IN THIS STUDY

Introduction

In this chapter, I present a discussion of the main themes that emerged from this study. Specifically, these themes are the role of context, challenges to implementing reading instruction in the mathematics classroom, and teaching practice that has been informed by research. In a discussion of the first theme, an examination of the context of the study includes both Mr. Merle’s unique background and the complexity of teaching a Grade 9 ESL Academic Mathematics course. The second theme emerged from the challenges that Mr. Merle encountered in his efforts to integrate reading in Grade 9 mathematics classes designed for different and distinct student populations. The discussion of this theme also includes Mr. Merle’s suggestions for encouraging other mathematics teachers to teach reading in their regular classrooms. The last theme is discussed in the context of Mr. Merle’s instructional approaches for using reading activities and strategies to facilitate students’ language development and reading comprehension. The discussion of the themes is supported by current curriculum policy documents, recent professional literature and empirical research.

The Role of Context

Patton (2002), and Stake (2005) state that qualitative research is highly dependent on the kind of case chosen for the study because the context of each case is unique and the role of the researcher is to capture as much detail as possible (i.e., individual characteristics and qualities of the situation under examination). In this study, the unique context was a function of both the teacher’s experience and the class composition. The context provided rich opportunities for the study as well as limitations to the study.
Needs Arising from the Specific Course

This study was most affected by the informant’s choice of classroom setting for observation. The primary goal of the study had been to describe Mr. Merle’s experience in teaching mathematics with and through literacy strategies and reading activities; however, the Grade 9 ESL Academic Mathematics course presented barriers to achieving the goal because the composition of the class resulted in reading and literacy being a lesser priority.

As Mr. Merle emphasized throughout the study, his first responsibility was to the explicit mathematics curriculum content standards for the course. Although it was also his responsibility to provide accommodations for students in terms of learning style, learning disability, and language, at the same time, the program for Grade 9 ESL Academic course was geared to high-achieving students who intended to continue studying mathematics throughout their secondary school education. Mr. Merle had anticipated that he would strive to create a classroom environment that facilitated ESL students’ English language development; however, he had not anticipated the students’ low mathematics achievement and their lack of familiarity with fundamental skills and knowledge. Early in the course, it became clear to Mr. Merle that he could not assume that the students had the prerequisite knowledge for learning material from the intended curriculum for the academic level course. The results of a district-level diagnostic test suggested that between one-third and one-half of the students enrolled in the class were misplaced in terms of academic level.

Given the extra barrier of their limited proficiency in English, it was clear that the students in Mr. Merle’s class were challenged on two levels:

The intent of this course was to focus on the literacy. We are not downplaying the math. We are still teaching a [Grade] 9 Academic course with some accommodations for language. The intent was to develop the language at the same time as math. But what has happened is that the language is definitely an issue but it is also the math. It is a huge issue for the half of the class. (FUI6, p.7)
Mr. Merle used the word ‘misplaced’ to describe the fact that students’ previous background or achievement meant that they were unfamiliar with large portions of curriculum content from previous grades—an intuitive conclusion based on Mr Merle’s professional judgement and confirmed by the formal diagnostic test. Mr. Merle believed that some of the students were, in reality, struggling with material from Grade 6-7. In spite of his efforts to support the students’ learning, the class average for daily quiz scores was consistently below 30%.

Throughout the entire observation period, Mr. Merle was trying to find ways to help the students to earn a mathematics credit. For example, he gave more time for completing assignments, quizzes, and tests; and provided students with additional supports (i.e., formula sheets, the Word Wall, unrestricted dictionary use, and conversation opportunities in their first language); and, scaffolded the mathematics problems for quizzes and assignments.

Mr. Merle was comfortable with making accommodations for the students; however, he was very concerned that he was compromising the integrity of the course because his adaptations went beyond the accepted levels of accommodation. In fact, Mr. Merle had to simplify the content to what he considered to be equivalent (in terms of level of difficulty) to an Essential mathematics program. The issue was that two programs, i.e., Academic and Essential, are not parallel (neither with respect to conceptual depth nor more importantly, in terms of topics and expectations). Mr. Merle was lowering his expectations and was continuing to deliver an adapted Academic program to students who performed at the essential level.

This situation caused Mr. Merle to worry that he could be disadvantaging those students in the class who were more mathematically able and who had aspirations to continue along the university-track course route through secondary school. He was certain that, although he took the curriculum expectations for the class from the Grade 9 Academic policy documents, he was planning lessons and using instructional strategies that were more targeted towards meeting the lower-achieving students’ needs. This dilemma created a lot of professional angst for Mr. Merle
and precipitated daily challenges to the implemented curriculum, including diminished attention
to the writing and reading strategies that had been the focus of Mr. Merle’s teaching practice.

As Mr. Merle stated, the only criterion used to place students in this particular program
was a measure of their level of English proficiency. Before the start of the course, the students
were not required to demonstrate their mathematics proficiency to the Grade 8 level. In some
cases, the students were placed in the class because it was age-appropriate, even though the
situation in their country of origin may have resulted in gaps in their schooling. The issues were
compounded because the course was new to the school and new to the teacher. The teacher was
the only instructor for the course; therefore, he had neither peer support nor professional support
from colleagues who were teaching the same course in terms of sharing materials and/or
experiences.

A recent policy document from MOE (2007b), *The Ontario Curriculum, Grades 9–12:
English as a Second Language and English Literacy Development*, highlights the importance of
assigning students to programs based on their English proficiency together with their proficiency
in prerequisite mathematics knowledge. The situation with Mr. Merle’s Grade 9 ESL Academic
course resulted in no one’s needs being met: not the teacher, not the low functioning students, and
not the high functioning students. If Mr. Merle attended to the curriculum policy expectations
only, up to 50% of his students could not participate in the instructional activities. On the other
hand, if Mr. Merle focused his attention on the low-achieving students, he was putting the other
50% of the class at risk of not having the opportunity to learn the content, skills and processes
that were prerequisites for the Grade 10 Academic Mathematics. Mr. Merle believed that could
not implement many of the interesting applications-based lessons he had previously designed and
implemented because they were beyond the mathematics knowledge and language facility of his
students, a situation that resulted in some frustration to his consistent efforts to use innovative
practices.
Contextual Influences Unique to Mr. Merle

Mr. Merle’s educational background and teaching experience. The informant for my study, Mr. Merle, was selected because of his commitment to reading development in the mathematics classroom; however, the data showed that Mr. Merle was unique not only because of his reading practices in the mathematics classroom, but also because of his own continuous professional development efforts. Indeed, Mr. Merle was actively involved in the mathematics community by attending and presenting at conferences and PD seminars, publishing his ideas in mathematics journals and action research, serving on school committees, participating in curriculum design and evaluation efforts, and teaching in-service courses at the university level.

Mr. Merle’s active involvement and duties required him to learn systematically about teaching theories and empirical research and to keep himself up-to-date on MOE policies. They also helped him to continuously reflect on and strive to improve his practice. He regularly used ideas from workshops, meetings, professional reading, and conferences in his classroom and established much successful collaboration with fellow educators, including the productive efforts between himself and Professor David Pugalee.

Mr. Merle has proven himself to be a lifelong professional learner. He completed a Master’s degree in Education, completed all of his coursework and one comprehensive examination in a PhD program, and was finishing a Master’s degree in Arts. The experience of being a graduate student has given him the opportunity to obtain research-based skills: searching for and identifying theories and conducting formal self-study. According to the data, Mr. Merle showed considerable expertise in conducting action research studies in his classroom. He had completed studies and published the results on two topics important to the mathematics education community: factors that facilitate the implementation of authentic assessments and the impact of using expository journal writing on students’ mathematical learning.
Kemmis and McTaggart (1988) state that action study requires teachers to: “make changes, observe their consequences, evaluate them critically, and modify plans for continuing improvement...[a process] that promotes continuing critical and self-critical reflection” (p. 44). Indeed, Mr. Merle demonstrated thorough, thoughtful and careful instructional preparation by studying the theoretical bases for his innovations, searching for strategies that had been field-tested and shown to be effective, developing customized handouts tailored to his students and the Ontario curriculum, reflecting on his own implementations, and recording student feedback and responses to improve his strategies.

Mr. Merle’s knowledge of professional resources and materials extended well beyond the limits of those regularly provided to all Ontario teachers through the MOE [e.g., Targeted Implementation and Planning Supports (TIPS)], the Literacy and Numeracy Secretariat, OAME, and the EQAO. Mr. Merle made extensive use of professional books and empirical studies about implementing reading (e.g., Barton & Heidema, 2002; Bay-Williams & Martinie, 2004). He showed excellent judgement by choosing reading strategies that would work well for him, focusing his energies on those strategies that he deemed to be the best fit, and adapting others within the context of his practice.

For instance, Mr. Merle chose to use three reading strategies presented in the TRM book: vocabulary development, analyzing supplementary text, and reflection strategies. He used bibliographies and other citations within the books in order to locate other resources and to evaluate the appropriateness of the suggested materials for each strategy. For example, he found the children’s literature and assignments in the MLG book to be well suited to his teaching style while he used variations on the Frayer Model, Word Wall, and crossword puzzle suggestions provided in the Think Literacy document. Based on his reflection on his own experimentation with the K-W-L chart (Ogle, 1986), he created his own 2-column chart for use in his own classroom, omitting the middle column which he found was redundant.
Mr. Merle’s approach to improve his professional practice through the action research process is well-recognized in the educational literature. Schön (1983) stated that practitioners from any fields should improve their practice by reflecting on their work and integrating innovations by thinking critically about their experience: “Reflection-in-action…is central to the art through which practitioner sometimes cope with the troublesome “divergent” situations of practice” (p. 62). He stressed that: “When someone reflects-in-action, he becomes a researcher in the practice context” (p. 68). Mills (2007) encourages adopting a professional disposition by adopting a stance as “continuous learners-in their classroom and of their practice” (p. 10). Kemmis and McTaggart (1988) and Van Zoest (2006) point out that teachers-as-researchers enhance not only their own practice but may make important contributions to existing educational research. Mills states the importance of sharing the results of one’s action research with both colleagues and the wider community. To this end, Mr. Merle was an enthusiastic and frequent presenter of his work through PD seminars, conference addresses, and published papers.

In sum, Mr. Merle’s familiarity with and participation in the academic community influenced his teaching practice and distinguished him from other mathematics teachers. It gives him the advantage of being familiar with innovations in mathematics education; having the skills and knowledge to appropriately judge the importance and efficacy of particular innovations and their implementation in his classroom; and contributing to his professional growth and confidence so that it became routine to introduce inventive interventions in his practice. For the purposes of my study, I focused on just one of Mr. Merle’s innovative practices: the integration of reading activities and strategies into his regular mathematics classroom.

Factors that motivated Mr. Merle to include reading strategies in his practice.

According to Mr. Merle, there were several factors that led him to focus on reading in the context of the mathematics classroom, the most significant of which was his own research into the effect of journal-writing. Mr. Merle found many benefits to be associated with journal-writing, the most
important of which was what he perceived to be the deepening of students’ conceptual understanding of key mathematics concepts. After he had experienced first-hand with his students the power of this particular literacy strategy, he was eager to critically examine the other side of the literacy coin: reading. His familiarity with the NCTM Standards, the MOE curriculum and other provincial and district level priorities (e.g., NCTM, 2000; Ontario Ministry of Education, 2005) supported his attempts to emphasize the development of communication skills.

Communication, which includes writing and reading, must be taught since it is one of the explicit mathematical processes on which students are to be assessed at the classroom level and on provincial assessments. The provincial curriculum states that “communication is the process of expressing mathematical ideas and understanding orally, visually, and, in writing, using numbers, symbols, pictures, graphs, diagrams, and words” (Ontario Ministry of Education, 2005, p.16). Students are expected to read and interpret mathematical communication as well as create original supporting mathematical text in problem solving contexts. Moreover, Mr. Merle concluded, based on his experience and action research studies, literacy instruction was not within the exclusive purview of the elementary teacher: literacy needed to be a part of the secondary curriculum, including the secondary mathematics curriculum.

From this teacher’s perspective, it is important to combine teaching mathematics and reading strategies because of the complexity of mathematics text—a type of text that differs from text in any other content area; and the benefits of teaching how to read. Mr. Merle understood the cognitive demands of mathematics text and the importance of facilitating students’ reading comprehension of this text. This point of view is also widely discussed by researchers and educators from different areas. Adams and Lowery (2007), Kirkpatrick and Makar (1980), O’Halloran (2000), and Schleppegrell (2007) point out that students need to obtain specific reading skills in order to comprehend mathematics text successfully. In addition, Adams (2003),
Barton, Heidema, and Jordan (2002), and Pugalee (2007) posit that mathematics teachers are responsible for helping students to read and comprehend mathematics text.

The unique experience of teaching mathematics with reading emphases. According to the data, Mr. Merle believed that the use of reading in his classroom had changed his teaching practice by giving him the opportunity to explain mathematics concepts more substantively. He believed that each of the reading strategies not only facilitated students’ comprehension, but also made learning mathematics more interesting, showed students the connections between mathematics concepts and the real world, and helped students to obtain mathematics knowledge on a conceptual level. The importance of making connections between mathematics concepts and the real world is underscored in the provincial curriculum: “making connections between the mathematics [students] study and its applications in their everyday lives helps students see the usefulness and relevance of mathematics beyond mathematics” (Ontario Ministry of Education, 2005, p. 16).

In addition, the mathematics problems posed after reading a poem or an excerpt from a poem or story were aimed at application of the mathematics concepts. For example, in the Holes’ assignment, students had the opportunity to see the connection between volume and the amount of dirt that the boys needed to shovel. The solution to the problem demonstrated to students how the difference of ½ " for the length of the shovel would make an enormous difference to the quantity of earth moved. Similarly, the assignment based on the book The Village of Round and Square Houses, appeared to help some students to make the connection between formulae for surface area and the purchase of building materials. In order to find the solution to this problem, students had to identify the components of the surface area formula and omit the base of the house.

In similar studies, Adam and Lowerly (2007), and Borasi et al. (1998) found that including reading children’s literature and mathematics-related text in the mathematics classroom,
helped students not only to better understand the scenario of the excerpts, but also encouraged the development of conceptual understanding of the mathematics concepts embedded in the text.

Indeed, in Mr. Merle’s lessons it was obvious that the students enjoyed listening to and talking about the novels. The excerpts or poems seemed to help to engage students in the task. However, the follow-up discussion with students consistently related more to the scenario of the story than to the implicit mathematics concepts. This could be attributable to the characteristics of the poem or story, since each observed example was fictional and lacked explicit connections to mathematics concepts in contrast to excerpts that were used in Adam and Lowerly’s and Borasi’s studies.

Mr. Merle described the advantages of the K-L chart (which he successfully used as a diagnostic tool for himself at the beginning of a unit and for summative assessment purposes at the end of a unit). He was convinced that this tool motivated students to reflect on their own understanding and, at the same time, taught them how to fill in their gaps. To this end, Mr. Merle was providing an important opportunity for them to learn a strategy stated as a goal in the provincial curriculum, i.e., teachers are required to give students opportunities to evaluate their work and learn how “to recognize when the technique they are using is not fruitful, and to make a conscious decision to switch to a different strategy, rethink the problem, search for related content knowledge that may be helpful, and so forth” (Ontario Ministry of Education, 2005, p. 14).

During the Grade 9 ESL Academic course, Mr. Merle found another advantage to integrating reading in the mathematics classroom. Specifically, he noticed that the reading strategies included accommodations that helped ESL students to learn English together with obtaining mathematics knowledge. Mr. Merle suspected that at some points students could not solve a mathematics problem because they did not know the translation of specific mathematics terms (e.g., outcomes) or they were not familiar with a grammatical rule for developing plural forms of English noun (e.g., vertex, and vertices).
Through Mr. Merle’s enacted lessons, the students used not only mathematics terms but also everyday language by being involved in collaborative discussions about the stories and poems. For example, while reading poem *Eighteen Flavors*, students shared their knowledge about different types of flavours. While reading the children book *The Village of Round and Square Houses*, students were engaged in a debate about what really happened in the village and what kind of consequences were attributable to the eruption of the volcano. Mr. Merle was proactive and purposeful in selecting words that he anticipated might be problematic for students in his class. This approach helped to demonstrate that he was on their side and wanted them to succeed, creating a friendly atmosphere in which students felt free to question words, expressions, and events they did not understand because of language.

Recent MOE documents [e.g., *English Language Learners/ESL and ELD Programs and Services: Policies and Procedures for Ontario Elementary and Secondary Schools, Kindergarten to Grade 12* (2007a) and *The Ontario Curriculum, Grades 9–12: English as a Second Language and English Literacy Development* (2007b)] suggest that Ontario secondary schools need to respond in two ways when teaching ELL in regular inclusive classrooms. First, they should provide intensive specialized second language instruction in segregated classes. Second, schools should include support for ELL within the context of all regular classes. It is the contention of the MOE that the focus on literacy and ELL instruction is best accomplished through teaching within the parameters of the disciplines: “an effective curriculum for English language learners integrates academic language and literacy skills with subject-matter concepts…so that students can gain as much momentum as possible as they progress to full participation in mainstream classes in the various subjects” (Ontario Ministry of Education, 2007b, p. 4).

This suggests that all teachers should focus on the following components in their lessons: listening and speaking; reading; writing; social-cultural competence and media literacy. It is believed that by giving students opportunities to read in the context area, there will be more
opportunities for students to increase their vocabulary base, build confidence in using language, and expand practice in communicating through written materials:

it is important that they have many opportunities to read a wide variety of text from diverse culture and variety purposes. By reading widely, students will develop a richer vocabulary, become more attuned to the conventions of written English in various genres, and increase their understanding of diverse word views...[and] widen their knowledge in all areas of the curriculum. (Ontario Ministry of Education, 2007b, p. 18)

Like all MOE publications, these documents include recommended teaching strategies to help teachers to address ELL’s needs. Some of these strategies were highly evident in Mr. Merle’s observed lessons. For example, the MOE document recommends the use of cooperative learning techniques “to allow students to work together as a team to accomplish a common learning goal” (Ontario Ministry of Education, 2007b, p. 40). In Mr. Merle’s classroom, the students routinely worked together to complete seatwork. The MOE document also suggests that guided reading “is a strategy that provides the scaffolding necessary for English language learners to tackle a challenging text” (p. 40). In fact, Mr. Merle modelled the process of reading by regularly asking students questions about the text in order to assess their level of understanding. The document also endorses the K-W-L chart “as a strategy that helps students build background knowledge and plans for further learning” (p. 43). Again Mr. Merle used his own K-L tool at the beginning of the Algebra unit. Another recommended activity, from the MOE document (that Mr. Merle’s used extensively) is the Word Wall, i.e., “lists of words displayed in the classroom for vocabulary development and word study” (p. 48). Even before his knowledge of the document and his experience with teaching ESL students, Mr. Merle was using all of these strategies in his teaching practice because they were grounded in research and well-documented in the literacy literature.

In sum, the data from this study suggests that Mr. Merle’s efforts to integrate reading not only take into account the concept of literacy across the curriculum but also achieve the goals of the MOE policy document for supporting ESL students’ learning by focusing on language
acquisition and inquiry within the context of mathematics. It is clear that Mr. Merle is a
specialized subject teacher who strongly believes in the importance of teaching literacy (both
reading and writing components) in his classroom. Although not a focus of this study,
Mr. Merle’s practice of integrating reading strategies may have had some positive effects on
students’ performance in the English environment. By the end of the observation period, it was
clear to the researcher that students were becoming more involved in posing probing questions,
actively participating in class discussions, and writing summaries from the stories and poems. For
example, during the last observed lesson (*The village of round and square houses*), students
questioned words they were not familiar with and actively discussed the scenario of the story. In
addition, during the same lesson, it was obvious that students used the Word Wall as a routine
part of their work.

Challenges to Implementing Reading in the Mathematics Classroom

Barton, Heidema, and Jordan (2002), Donahue (2003), Kajander and Lovric (2005), and
Kenney et al. (2005) posit that mathematics teachers do not consider teaching students how to
read to be a priority. Researchers present arguments that show how and why it is important to
include reading instruction in the regular mathematics classroom; however, none of their
arguments answer the questions “Why do mathematics teachers not focus on this issue?” and
“What factors are obstacles to mathematics teachers’ efforts to integrate reading activities into
their practice?” In the following sections, I discuss the challenges that Mr. Merle encountered
during his efforts to include reading in his classroom, mathematics teachers’ resistance to
integrating reading, and suggestions to encourage more teachers to include reading in their
classroom from Mr. Merle’s perspective.
Mr. Merle’s Challenges in Integrating Reading Strategies

In this section, I present challenges that Mr. Merle faced while teaching two different Grade 9 programs: the Applied Mathematics course and the ESL Academic Mathematics course. I separate the challenges between these two courses because the implementation in the Grade 9 Applied course was Mr. Merle’s first attempt to incorporate reading, and best illustrates his primary challenges. In contrast, the implementation in the Grade 9 ESL Academic course illustrated the challenges that Mr. Merle faced when adapting his previously developed materials for use in another context.

The Grade 9 Applied Mathematics course. Based on his experiences with and reflections on the Grade 9 Applied Mathematics course, Mr. Merle opined that the main challenges that he faced to routine integration of reading strategies and reading-based activities were the following: adapting to a continually changing current mathematics curriculum; finding resources (e.g., professional books and journal articles) with sample materials to support reading strategies in the mathematics context, and locating rich ancillary materials (e.g., children’s books, newspaper articles, teen fiction, poems) on which to base mathematics lessons; having an inadequate literacy background; and dealing with students’ resistance toward reading in the mathematics classroom.

It appears that Mr. Merle’s challenges were connected and each demanded the expenditure of considerable time for research, original materials development, and professional learning.

Mr. Merle’s efforts to complement and supplement traditional textbook lessons through the use of literature and popular press articles required a significant investment of time. There are some mathematics educators (e.g., Burns, Pappas, and Anno) who have authored children’s books that have explicit mathematics titles, with content and extensions to learning activities; however, these works are small in number and are primarily intended for elementary school-aged students. Thus, Mr. Merle turned to professional books, empirical studies, and teachers’ journals in order to find articles about how to use children’s literature as well as lists of suggested titles and related
instructional materials. His fortuitous collaboration with Professor David Pagulee augmented Mr. Merle’s knowledge of appropriate titles and authors.

Mr. Merle was emphatic that without the support and suggestions from this professor he would have been unable to succeed in his attempts to include reading strategies and reading-based activities in his mathematics classroom. However, it is unlikely that the typical mathematics teacher would have or make the time to seek out such elusive materials with their implicit connections or have the opportunity to establish such a productive collaboration. Mr. Merle agreed that the accessibility of resources was undeniably a nuisance for himself but more importantly, represented an obstacle for more mainstream teachers.

Mr. Merle believed that the barrier to the integration of reading strategies and reading-based activities in the mathematics classroom was not only his own literacy background and formal preparation for teaching literacy, but the limited literacy pedagogical base across the mathematics education teaching community. To address his own professional limitations, Mr. Merle tried to enrich his professional background by reading research-based literature about integrating literacy in the context of specific disciplines. He did not want to provide instruction about a particular strategy or incorporate an activity without acquiring for himself a considerable amount of foundational knowledge. Ruddle and Unrau (1994) state that for teachers to include reading strategies and teach reading processes, they must be knowledgeable about the strategy itself and have an understanding of which strategies might be appropriate in different situations.

Although Mr. Merle encountered some students’ resistance to the use of literacy tools and reading activities, his reflection on practice (a routine professional activity cultivated through years of action research studies) helped him to realize the importance of providing an explicit explanation to students about the goal of learning these strategies for lifelong learning and success in mathematics. This became a particularly important focus for literacy instruction that he
designed for ESL students by emphasizing that reading would lead to a better understanding of English, inside and outside the mathematics classroom.

*The Grade 9 ESL Academic Mathematics course.* Mr. Merle anticipated that he would be able to use previously researched and developed materials from the Grade 9 Applied course for learning activities in the new Grade 9 ESL Academic course by making some slight modifications to the original worksheets or reading-based activities. However, it turned out that the materials were not easily transferable to the other curriculum and a different student population, even after considerable revision.

In fact, while creating the Word Wall, Mr. Merle had to refer back to the Grade 6-7 curriculum and select terminology from the elementary mathematics curriculum expectations to add to the Word Wall for student reference and use. Mr. Merle pointed out that under normal circumstances, a teacher of Grade 9 students at the Applied or Academic level could be confident that basic terminology had been taught in previous grades. However, the complex student background in the Grade 9 ESL class meant that the Word Wall was much larger than in previous years and included many examples that were basic to mathematics in the Junior and early Intermediate divisions.

Mr. Merle also mentioned that under normal circumstances, the worksheets and activities that he had developed for use with Grade 9 Applied students (many of whom had diagnosed communication disabilities) should have been highly appropriate for and readily transferable to ESL students who also struggled with communication in terms of their lack of proficiency in English language. Mr. Merle explained that the handouts provided a lot of support because they included words printed in bold or italicized font, e.g., hints, and formulae. However, students in

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7 In Ontario, Junior Division is defined as Grades 4 to 6, and Intermediate Division is defined as Grades 7 to 9.
this particular class, who lacked both mathematics content knowledge and language proficiency, demonstrated difficulties with solving tasks even when given open access to these information sheets in spite of the fact that they included many explicit supports.

The largest hurdle in the Grade 9 ESL Academic class was a consistent shortage of time. To address students’ needs, Mr. Merle provided extensive instructional support, using language development strategies formally (while teaching) and informally (in conversation with students). Moreover, he routinely had to teach, rather than review, prerequisite concepts and procedures. This was time-consuming and did not allow Mr. Merle to include reading strategies and reading-based activities in the same way he had planned to implement them.

He was continuously behind in terms of the overall course schedule and daily lesson plans. As a result, Mr. Merle’s overall concern was that he would not be able to finish the course requirements and thus the students would be disadvantaged during common examination situations and in future courses. Content delivery, not instruction in reading strategies or the use of reading activities, was his priority. In spite of these pressures, Mr. Merle did use a number of language strategies, albeit in highly abbreviated or simplified formats.

Even for Mr. Merle, a teacher who is passionate about using reading strategies in a self-study context; willing to invest time and effort to develop high quality instructional materials; and, has previous experience and resources about reading strategies and reading-based activities on which to rely, the challenges to implementation are considerable. In spite of these challenges Mr. Merle refused to abandon his interest in literacy and communication in the mathematics classroom, acting whenever possible on his belief that reading strategies and reading-based activities should be an important part of his practice; and, on his hope that such learning experiences could facilitate students’ mathematical learning processes regardless of achievement level or grade.
Mr. Merle’s Suggestions for Encouraging Mathematics Teachers to Teach Students how to Read

Mr. Merle believed that his experiences in integrating reading strategies and reading-based activities in his classroom authenticated his observations about why mathematics teachers resisted top-down efforts to implement literacy, in general, and incorporate these strategies, in particular. By sharing his own first-hand experiences and his research-informed reflections on those experiences, Mr. Merle believed that he could simultaneously support some of the teachers’ concerns and counter their reasons for non-adoption of literacy priorities.

As a department head and mathematics education leader, Mr. Merle was well-informed about the professional demands placed on teachers by the MOE, EQAO, school district and school administration team, parents and students. In fact, he shared many of his peers’ struggles and concerns about including reading strategies in practice. According to Mr. Merle, the mathematics teachers in his department shared a belief with most of their provincial counterparts: literacy was not a part of their professional teacher education, teaching responsibility or instructional practice.

Mr. Merle speculated that mathematics teachers have a well-established teaching style that is centered on content. Most, he contended, see neither the room nor the need for a literacy focus. Indeed, Mr. Merle’s efforts confirm that incorporating reading in the mathematics classroom requires enormous efforts by teachers, regardless of whether the focus is on developing reading strategies or designing reading-based activities to scaffold, complement, supplement, and extend their lesson plans. This means that mathematics teachers would need to spend enormous amounts of time to revise their lesson plans and develop reading strategies and reading-based activities to neatly fit into their teaching style in addition to their routine teachers’ duties.

The new Ontario mathematics curriculum was introduced in 1998/1999, then revised for Grades 1-8 and for Grades 9-10 in 2005, and for Grades 11-12 in 2007 (Ontario Ministry of Education, 2005, 2007c). Given the rapidity of change, it is understandable that mathematics
teachers’ priorities focus their energies and attention on becoming familiar with and implementing the new curriculum expectations. Clearly, the integration of reading strategies and reading-based activities would come further down their list of priorities.

Mr. Merle strongly believed that some mathematics teachers recognized the value and importance of incorporating literacy strategies and activities into their instructional practices. They, he believed, included strategies to reinforce the pronunciation and spelling of mathematics vocabulary. It would appear that vocabulary development strategies are the easiest reading strategy to implement. Indeed, this statement is not only illustrated by Mr. Merle’s observed practice but also by the results of Carter and Dean’s (2006) study that showed that mathematics teachers preferred to focus on vocabulary development strategies rather than decoding or comprehension strategies. It would seem that vocabulary development strategies are both intuitive to mathematics teachers’ practice and a natural fit to the curriculum, while other comprehension strategies are less familiar and accessible to mathematics teachers.

Mr. Merle pointed out that the MOE, EQAO, Literacy and Numeracy Secretariat, and school administrators, as well as provincial-, district- and school-level mathematics education leaders needed to provide adequate support. Supports, in the form of PD seminar and resources, could change mathematics teachers’ attitudes toward implementing reading in their classroom and make them more confident about trying proven strategies. First, there was a need for PD seminars and workshops during which mathematics teachers could present the results from their own experiences with integrating reading strategies and reading-based mathematics learning activities in the classroom and share their already-developed strategies and handouts. According to Mr. Merle, such seminars and workshops would be more relevant to mathematics teachers because they represent actual implementations in real mathematics classrooms with real students rather than: “a consultant with an English background who is basically sharing his or her
knowledge of how to promote literacy, but workshops specific to mathematics nobody is doing that” (II, p. 4).

Secondly, mathematics teachers, Mr. Merle believed, need hard data to convince them that innovative practices have a proven impact on student achievement. Before they will ‘buy in’ to the latest mathematics education fad, teachers want to see the results from classroom-based empirical studies, in their own subject speciality, about how the touted practices could and should influence students’ mathematics achievement. Most of the journal articles and professional teachers’ books, that refer to reading, focus on suggestions and tips of how to integrate reading strategies but there are very few empirical studies which suggest a correlation between the use of reading strategies and students’ mathematics achievement.

Teaching Practice that Has Been Informed by Research

The discussion of this theme is based mainly on the theoretical framework and research studies related to strategies and targeted instruction for helping students to comprehend text in different content areas. I have named the theme ‘Teaching Practice that Has Been Informed by Research’ because of Mr. Merle’s tremendous efforts to develop his own professional knowledge about literacy theory in the context of his own subject specialty: mathematics. Mr. Merle’s instructional strategies for integrating reading were in two main categories: general reading strategies and strategies specific to mathematics text.

Mr. Merle’s Explicit Goal-Setting

Borasi et al. (1998) suggest that before integrating any reading strategies, mathematics teachers should have a clear goal for the activities and should be highly familiar with principles underlying the reading activities. In their study, the researchers developed a program in which they introduced mathematics teachers to a range of reading strategies and reading-based activities. They provided teachers with lesson plans for a unit, along with appropriate mathematics-related text and used a workshop format to give the teachers opportunities to discuss the activities. The
purpose of this professional development program was to familiarize mathematics teachers with
the instructional tools and concrete materials that were to be the basis for the literacy strategies
that they would be implementing in their classrooms.

Unlike the teachers under study by Borasi et al. (1998), Mr. Merle did not have the
advantage of support from experts. He had to learn about why and how to integrate reading
strategies on his own. To assist in this self-directed initiative, Mr. Merle developed and used a
planning template that explicitly listed reading strategies and reading-based activities side-by-side
with the curriculum expectations from the policy documents and textbook themes and chapters.
He used reflection on practice and his professional judgement to modify these strategies for his
practice and classroom contexts and employed each of these strategies strategically, in a specific
sequence.

Mr. Merle tried to implement reading naturally by developing his instructional plans to
accommodate reading strategies and reading-based activities when the content opened the door
for a seamless integration opportunity. In almost every case, Mr. Merle’s goals for the
mathematics and the literacy learning for a particular lesson were the same. Moreover, he used
reading strategies for regular classroom learning and assessment activities. Mr. Merle took
enormous strides to include such strategies and activities into all stages of his professional
practice: from the earliest stages in unit planning to summative assessment and made literacy an
important part of his regular classroom practice.

According to Mr. Merle, his use of reading strategies was dependent on the mathematics
topics in the unit. The Algebra unit included a lot of vocabulary development strategies, in
contrast to the Measurement unit which was best augmented with ancillary text. Results of the
study show that in order to include reading-based activities, teachers need to find children’s
literature or excerpts from the popular press that supplements the mathematics topics and relates
directly to the curriculum expectations. Finding such reading material is not an easy task.
Mr. Merle’s practice demonstrated a well-organized system for developing reading literacy. Mr. Merle’s template was, for him, an explicit prompt, drawing his attention to his own professional goal to include reading strategies as the opportunity arose. He developed his own system for implementing each of these strategies by adapting and combining activities and by relying on a variety of timely and appropriate ancillary readings taken from a range of trusted resources: professional practice books, MOE support documents, refereed journals, and teacher-oriented publications. Mr. Merle had a preferred sequence for integrating reading strategies and reading-based activities in both individual units and for the course overall.

For example, he established that the K-L activity occurred at the beginning and the end of the unit. The Word Wall was used extensively at the beginning of each new topic but served as an ongoing support throughout individual units and the course. He used his own professional judgement to develop a version of the Word Wall that fit comfortably into his own practice by reflecting on his previous experiences, modifying suggestions from the teacher guides and professional publications, and the curriculum policy document.

Mr. Merle carefully took into account the students’ location on the learning continuum for any concept before using particular reading activities. For example, he did not introduce the Frayer Model until he was confident that the students were familiar with particular mathematics terms and possible representations and meanings. He tried to make sure that students understood his purpose for using particular strategies and guided students through each process. For instance, when the students were required to read an excerpt from a book or read a newspaper article, before being assigned to work in pairs or individually, Mr. Merle realized the importance of providing students with a mental image of what “reading” looked like and how one did it: by reading aloud, asking oneself questions about particular words, referring to a dictionary or glossary, activating prior knowledge, and reflecting on previous passages for clarification.
Mr. Merle’s practice is well-grounded in the literature. The importance of giving students the opportunity to see and then practice reading strategies in action is widely supported in the reading and comprehension research (National Reading Panel, 2000). The literature indicates that at the first stages in reading instruction, the teacher should demonstrate explicit reading strategies. In addition, according to National Reading Panel Report, students with reading difficulties require direct instruction. Clearly, the ESL students in Mr. Merle’s class were experiencing reading difficulties, most obviously because of their level of English proficiency. Palincsar and Brown (1984) state that teachers should begin by modelling the reading process for students and suggest that once students have learned them, they will be able to reapply these modelled strategies.

Mr. Merle’s approach to facilitating the learning process in general, and teaching reading strategies in particular, focused on providing gradual but explicit guidance and support for students with the aim of meeting their needs. His teaching style embodied the constructivist approach to learning. The data show that Mr. Merle routinely used the scaffolding model of teaching for facilitating the development of students’ reading strategies and content-based conceptual development. Mr. Merle planned and implemented activities by continuously assessing and responding to his students’ apparent level of understanding and their ability to apply information successfully.

Mr. Merle’s Instruction of General Reading Strategies

In general, Mr. Merle’s reading instruction was focused on helping to develop reading strategies that are necessary for comprehending text in any content area. This was especially evident when he demonstrated for students his approach to reading supplementary text. While reading ancillary materials, Mr. Merle applied a variation on reciprocal teaching strategies (Palincsar & Brown, 1984). In the study by Palincsar and Brown, both the teacher and the students read aloud from the text and discussion ensued because of questions from the students as well as prompts from the teacher. The dialogue helped the teacher to identify students’
misconceptions and to offer appropriate support. In my study, Mr. Merle used read-aloud strategies and classroom discussion; however, he did not call upon students to read aloud. In his class, he always read the text and students always listened.

Why did Mr. Merle do all the reading by himself? Mr. Merle did not have sufficient quantities of books for students to have their own copy with which to read along, individually or in pairs. Second, Mr. Merle strongly believed that he did not have the opportunity to demonstrate to students enough reading strategies and was reluctant to ask them to apply these strategies on their own. The limited time of my data collection did not give me the opportunity to observe lessons in which, according to Mr. Merle, students would feel confident and comfortable enough to read in pairs. He was planning to resume these kinds of lessons for both a Grade 10 ESL Academic and Essential mathematics courses with the same students.

While modelling how to read poems, stories, or excerpts from novels, Mr. Merle provided students with well-known reading strategies described by many researchers in the field of reading. One group of researchers, Dole et al. (1991), identified four effective reading strategies that facilitate reading and comprehension of text: determining important and unimportant information; summarizing information; drawing inferences; generating questions; and monitoring comprehension. Mr. Merle successfully modelled for his students the behaviour of an active reader. He demonstrated a range of strategies that involved himself and his students in the thinking process as they travelled through the text using open discussion. Mr. Merle’s modelling activities also gave students a first-hand experience upon which to build a strong vision of a good reader. Cook (1986) and Irvin (1998) point out that the difference between a good reader and a poor reader is the ability to control the process of reading by asking questions and by activating prior knowledge.

Mr. Merle successfully utilized each of the strategies identified by Dole and colleagues (1991). He asked students to write a summary of both the short story and the poem after he read
them. He showed the students how to pose questions and clarify words they did not know. Mr. Merle mostly posed questions about the meaning of words instead of the meaning of passages. He realized that some of the words could be barriers for ESL students and that without his intervention and explanation there could be a general misunderstanding of the whole story.

In addition, he taught the students in his class how to predict the scenario of a story. He used the title, illustrations, and foreshadowing sentences to ask the students “What do you think happens next?” Mr. Merle taught students how to identify the main idea from the text. He summarized each paragraph by synthesizing the main points. For example, while reading The Village of Round and Square Houses, he stopped and reminded students what happened in the previous paragraphs and outlined the connection between events that had happened in this paragraph and the whole story. Mr. Merle implemented one monitoring reading strategies, i.e., the K-L chart activity; however, he used this strategy separately from reading the passages in contrast to the original recommendation (Ogle, 1986).

These reading strategies are also known to contribute to the effective comprehension of the text. Some of them were identified by Anderson and Pearson (1984) and Kintsch (1986). For example, Mr. Merle’s questions about the titles of the ancillary readings activated students’ prior knowledge about *flavours* and *villages*. This strategy helped students to build a bridge between the knowledge stored in their memories and new information presented in the text by creating an appropriate schema (Anderson & Pearson). Kintsch, Barton and Heidema (2002) ascribe a significant role to activating both prior knowledge and students’ experience in facilitating comprehension of the text. My data showed that students from different countries brought different interpretations of words to the exercise. For example, some of the students believed that a *village* was a place where poor people lived. Mr. Merle did not evaluate or judge such a response, but considered how the students’ background and experience influenced the conceptions that they brought to the learning process.
These strategies also represent Mr. Merle’s efforts to help students make strong connections between three communication modes: reading, listening and writing. As Pugalee (2005, 2007) asserts, the communication modes work together. In this study, it is clear that teaching reading naturally involves activating the other communication modes, particularly listening and writing. In a similar study, Borasi et al. (1998) used three activities after reading the text: speaking, writing, and drawing. As suggested by Borasi et al.: “each of these strategies invites students to explore the texts read through a different symbolic means-oral language, written language, visual images, and actions, respectively” (p. 302). Mr. Merle’s strategies provided students with concrete ways to actively engage in making sense of the text by listening, discussing, and writing.

Mr. Merle’s Instruction of Reading Strategies Specific to Mathematics Text

Mr. Merle’s practice was focused on using additional literature as an aid to develop students’ deeper understanding of mathematics concepts and on introducing reading strategies to improve students’ reading comprehension of supplementary text. However, some of the activities also seemed to help students to better comprehend mathematics text. According to Kirkpatrick and Makar’s (1980) classification of reading skills in the mathematics context, there are general and specific skills which are an important part of the reading process. In the previous section, I discussed the strategies that helped to develop general reading skills that are necessary for comprehending text in any content area, i.e., noting details, following directions, organizing and relating facts, judging the relevancy of information, recalling important facts, locating information, and forming visual impressions (Kirkpatrick & Makar, p. 12).

Kirkpatrick and Makar (1980) list the following specific skills for mathematics contexts: adjusting vocabulary to include words specific to mathematics and words with unique meanings in mathematics; reading the vocabulary of mathematics symbols and variables; reading mathematics text carefully and slowly; reading charts, graphs, and tables; understanding word
problem solving; and responding to the particular characteristics of mathematics reading materials (e.g., textbooks, journals). Mr. Merle addressed some of these skills. Specifically, he focused on clarifying and building mathematics vocabulary; analyzing the mathematics textbook; decoding mathematics problems; and providing students with opportunities to read different types of text.

Mr. Merle made extensive use of vocabulary development in his course. He believed that if students did not understand mathematics terms then they would be unable to solve mathematics problems. I observed many such scenarios, including a situation in which students seemed to be confused by the meaning of ‘square’—using the word to mean a power or exponent instead of a geometrical figure. Many researchers and educators state the importance of emphasizing mathematics vocabulary for words with ‘double-meaning’ and unusual words in everyday English language words (Adams, 2003; Barton, Heidema, & Jordan, 2002; Morgan, 1999; Pimm, 1987; and Rubinstaine, 2007) because of their impact on students’ understanding of the mathematics problem and text.

Mr. Merle’s focus on vocabulary development strategies could also be explained by the lasting influence of the 1985 curriculum guideline which explicitly identified ‘mathematics language’ as a process component. This curriculum policy document also mandated that instruction in mathematical vocabulary and symbols was to be included as a priority: “Each unit in the course should be analyzed to identify…vocabulary and symbols” (Ontario Ministry of Education, 1985, p. 17). Furthermore, this document specified that three categories of mathematics vocabulary and symbols that should be taken into account during teaching and learning mathematics: “words and symbols that have both everyday meaning and special meaning in mathematics…that have unique meaning in mathematics… [and], that are unique to mathematics but that have multiple interpretations within mathematics” (p. 18). In many ways, Mr. Merle’s practice of teaching vocabulary reflects the statement from this document rather than the communication process in the new 2005 curriculum document. Since Mr. Merle completed
his teacher education and entered the teaching profession during the tenure of the 1985 OS:IS mathematics curriculum, these early experiences may have strongly influenced his beliefs, teaching style and practice.

Mr. Merle used many activities, including dictionary supports, glossary use, Word Wall displays, cross-word puzzles, and Frayer Model tasks, to support the students’ knowledge of mathematics terms. The vocabulary development strategies were naturally integrated into his practice. However, most of the time, vocabulary development strategies were isolated from reading mathematics text. This is in contrast to Adams’ (2003) suggestion that vocabulary development strategies should be closely linked to the reading of mathematics text.

In the first lesson, Mr. Merle used an activity to introduce students to their mathematics textbook. A scavenger hunt was designed to make students aware of the organization, language and graphic organizers used by the book’s authors. Barton, Heidema, and Jordan (2002) and Pugalee (2007) point out that a mathematics textbook has its own structure, feature, and style which include both specific mathematics language and some common textbook features: “texts use signalling devices such as headings and subheadings to chunk key concepts. These devices can help students identify key concepts and approach reading sections of text with an organization scheme in mind” (Pugalee, p. 26). Researchers stress the importance of introducing these sections and any given textbook’s particular style to students since: “[t]eaching students to recognize a text's style and then use it to aid comprehension can improve student learning” (Barton, Heidema, & Jordan, 2002, p. 27).

In addition, Kinsch (1986) showed that there two types of text representation: text-based and situational models, each of which has an impact on students’ understanding. The situational model requires activating students’ prior knowledge. The text-based model requires students’ familiarity with the structure of the text. At the same time, Brown (2003) found that some elements of the textbook including glossaries, tables of contents, indexes, bolded and italicized
words serve as navigational tools for students. Mr. Merle’s use of the scavenger hunt activity was clearly intended to help students become aware of and familiar with their book’s particular navigation tools. In fact, before this activity, the students were unaware of many elements of the textbook, including the student answer section.

Mr. Merle consistently used oral explanations to decode mathematics problems by wondering aloud about the various terms presented in word problems. For example, Mr. Merle focused on the definition of each term from the problem, and then simplified the definition. Mr. Merle regularly paraphrased word problems in his own terms and encouraged students to do the same. Vilenius-Tuohimaa, Aunola, and Nurmi (2008) found that the steps in decoding mathematics problems contribute to comprehension of the overall problem. In their study, they investigated the interaction between mathematics word problem-solving skills and reading comprehension in Grade 4 students.

One of the findings shows that technical reading skills (e.g., flexible word recognition, decoding skills, and text reading speed) are crucial for both mathematics word problem-solving and reading comprehension: “a reader with poorer decoding skills struggles more with the text itself, resulting in poorer performance in tasks requiring logical reasoning strategies” (Vilenius-Tuohimaa, Aunola, & Nurmi, 2008, p. 422). Since a principal goal of learning mathematics is to apply mathematical principles and processes in problem solving situations, the ability to decode and comprehend what is being communicated via mathematics text plays a significant role in students’ mathematical success and achievement.

During the observation period, Mr. Merle did not include strategies that might develop students’ ability to read symbols or formulas or work through the dense information of the mathematics text. Instead, he used literature which did not directly include terminology, symbolism, representations or conventions typical of mathematics text. In similar studies, Borasi et al. (1998) and Adams and Lowery (2006) used mathematics-related text and children’s
literature, respectively, separate from the textbook; however they selected ancillary readings that included explicit mathematics and mathematical themes. In these studies, students had the opportunity to read mathematics in the context of a story—something that I did not observe. For example, Mr. Merle mostly employed literature which did not have an explicit mathematics message—the story was the impetus for creating related mathematics questions.

In stark contrast to Mr. Merle’s approach, some researchers strongly recommend that teachers focus on reading specific mathematic text instead of reading biographies or children’s literature (Adams, 2003; Barton, Heidema, & Jordan, 2002). These researchers believe that much ancillary reading material use in mathematics instruction has more to do with context than mathematics. They believe that such printed resources do little to support students to read mathematics text with the dense presentation of mathematics terminology, symbols, formulas and conventions (Österholm, 2006).

This chapter detailed the analysis of contextual influences, Mr. Merle’s challenges, and Mr. Merle’s research-informed practice of integrating reading strategies and reading-based activities in his regular mathematics program. The next chapter of this thesis summarizes this analysis and outlines implications for further research in this field of study.
CHAPTER SIX: IMPLICATIONS AND CONCLUSIONS

Introduction

This chapter summarizes the findings of this study and discusses the implications of this thesis. Specifically, this chapter consists of three sections: the summary of the findings from this research; the implications of the study for mathematics teachers, teachers’ professional development and further research in this field; and a final conclusion of the thesis. In addition, this chapter outlines the connection between the research questions that framed the study and the findings that emerged after analyzing and discussing the data.

Findings of the Study

First, teaching in a Grade 9 ESL Academic Mathematics context influenced Mr. Merle’s practices and brought another layer of complexity to the original study, which had been to observe and examine the regular integration of reading strategies and reading-based activities by an experienced teacher into routine (to this teacher) ways to complement, supplement and extend students’ mathematics learning experiences and opportunities. The unexpected nature of the particular Grade 9 course, specifically, the students’ limited mathematics and English proficiency shifted the focus of this study from issues of integrating literacy across the curriculum to the challenges of using innovative language-based practices in the face of demanding provincial curriculum requirements and accountability measures, and the exceptionally high needs of low-achieving ESL students.

Mr. Merle’s practice of integrating each reading strategy demonstrated possible ways to teach English to ESL students with learning mathematics, a practice that is endorsed and supported by recent MOE documents. Mr. Merle’s experience with teaching this particular Grade 9 class demonstrates the importance of taking into account students’ achievement levels in mathematics before assigning them to specific mathematics courses that are geared to separate academic levels. In this particular case, students were assigned to this class because of their level
of English proficiency, not their mathematics achievement. This suggests that the ESL designation superseded the Grade 9 Academic Mathematics designation—a decision that had huge implications for the teacher and all of the students: those who were expecting an academic-level mathematics course, and those who were expecting an ESL course with some mathematics. This study clearly showed the consequences of student misplacement on Mr. Merle’s teaching dynamic.

An additional finding relates to another dimension specific to the context of this study: Mr. Merle’s unique background and his commitment to integrate literacy, specifically, to teach writing and reading in mathematics class. Mr. Merle’s self-motivated determination to continue to grow professionally and his active involvement in many circles within many mathematics education communities provided him with enormous advantages and opportunities in comparison to regular mathematics teachers in terms of integrating timely curriculum innovations. As the data showed, his educational background and professional network made a huge difference to Mr. Merle’s practices and teaching foci. Mr. Merle’s classroom-based action studies of integrating writing and reading had enormous impact on his teaching style and professional growth. Indeed, he has looked far beyond the mandatory mathematics curriculum policy documents to inform his practice, using ‘hot-off-the-press’ MOE documents and professional resources to achieve a vision of communication and cross-curricular literacy in mathematics class.

From Mr. Merle’s perspective, incorporating reading in the mathematics classroom was important not only because of the unique demands of mathematics text but also because of the opportunities these strategies afforded him as a mathematics teacher. His practice clearly showed that using strategies for developing reading literacy enriched his teaching style and positively changed the learning process for students. Thus, his application of literacy practices broadened the repertoire of strategies typically available to the secondary mathematics teacher. In addition, reading strategies and reading-based activities helped Mr. Merle to make mathematics more
interesting, accessible and relevant for all of his students, and, it helped him to concentrate on the
development of conceptual mathematics knowledge in contrast to a focus on skills and
procedures.

Mr. Merle’s experience with integrating reading strategies in his classroom illuminated
for him the main challenges that other mathematics teachers would face in including literacy in
their regular classroom. The main challenge was time: time to prepare lessons that support
literacy; managing the time required to develop supporting materials for lessons that include
reading activities; managing instructional time when a novel task, strategy or approach is
introduced to the classroom routine; and, finding the time to adequately address the curriculum
expectations for the course. In addition, he did not have a literacy background which made him
question whether or not he was correctly applying the strategies that he had read about and
incorporated into self-designed materials.

From Mr. Merle’s perspective, mathematics teachers understand the value of literacy;
however, they resist integrating literacy strategies because they interfere with their routine
teaching style and because of the dearth of ready-made resources. Using his own department
members as examples, Mr. Merle stressed that dedicated mathematics teachers are overloaded
with meeting the needs of a curriculum that is constantly changing, and because they have other
teaching or professional responsibilities that leave very little time for other innovations, including
a focus on reading or writing in the mathematics program. Because their energies are directed to
other priorities, most mathematics teachers are not familiar with either the theory or the
empirically-demonstrated benefits of integrating reading literacy and thus may not see the
relevance of including reading strategies in the mathematics classroom.

Findings of this study demonstrate that even for Mr. Merle, who has a rich educational
background and strong, empirically informed beliefs about teaching mathematics with a focus on
reading, the actual implementation was fraught with challenges. Mr. Merle integrated reading in
the Grade 9 Applied Mathematics course and thought that he would be able to transfer or scale those experiences to the Grade 9 ESL Academic course; however, different course requirements and classroom demographics created new challenges that involved major adaptations of his previously-developed materials to meet both the students’ level of knowledge and the curriculum expectations for the course.

Mr. Merle agreed that literacy, specifically, reading and writing, was an important emphasis in the recent MOE mathematics curriculum documents. Nonetheless, he contended that while these documents provide a vision, they fall far short in terms of providing specific and practical ideas about when, how and why to incorporate literacy strategies in the mathematics classroom. Mr. Merle suggested that mathematics teachers should be provided with ready-made materials and menus of possible scenarios in which to use particular strategies.

The findings of this study also demonstrate that a teacher must find the best fit between research-posited strategies and his or her practice. Mr. Merle adapted and accommodated three strategies for use in his day-to-day practice: vocabulary development, reading additional materials and reflection prompts. Mr. Merle actively sought out appropriate activities and reading materials through his own exhaustive research and developed handouts based on what he had learned; still, a large number of strategies were excluded.

The findings of this study show that Mr. Merle’s attempts to focus on reading and literacy are strongly reflected in his lesson plans and in his classroom practices. Mr. Merle seamlessly integrated many reading strategies as part of his everyday classroom routine. The data suggest that not all mathematics units are well-suited to the incorporation of reading strategies. According to Mr. Merle, using additional materials requires appropriate mathematics topics. As for vocabulary development strategies, the findings of the study suggest that every lesson could contain some activities. The important aspect of Mr. Merle’s practice is that he utilized the
scaffolding approach to teach not only mathematics concepts but also reading strategies by reflecting on both students’ level of knowledge and English proficiency.

This thesis reports that Mr. Merle focused primarily on teaching how to read supplementary text rather than teaching how to read specific mathematics text. Indeed, it should be noted that the ancillary materials I observed were narrative and fictional, not technical presentations using mathematics conventions. Mr. Merle’s methods for teaching students how to read additional materials utilized a version of the reciprocal teaching approach (Palincsar & Brown, 1984) and included well-known reading strategies grounded in the research literature. The main idea of modelling these reading strategies was to give students an example of how to be an active reader and provide them with the range of strategies that they would be able to use not only in the mathematics context but also in any other subject disciplines and in their future life. In addition, Mr. Merle’s integration of both reading strategies and reading-based activities showed the strong connection between communication modes such as listening, speaking, and writing.

Unfortunately, Mr. Merle did not address the issue of teaching reading strategies that developed all specific reading skills believed to be necessary for comprehending mathematics text (Kirkpatrick & Makar, 1980). He included some of them: developing understanding of specific mathematics vocabulary, introducing students to the structure of mathematics textbook, and decoding mathematics problems; however, Mr. Merle did not include in his practice, explicit lessons that provided instruction about reading symbols, graphs, and other mathematical representations or introduce other conventions of written mathematics text.

Implications of the Study

The findings of the study cannot be generalized because the research was about one mathematics teacher’s attempts to teach mathematics through the use and with the support of reading strategies; nonetheless, some findings of this thesis may have valuable implications for
both practitioners and researchers. In the following sections, I describe some considerations that emerged through this study.

**Implications for Mathematics Teachers**

Since 1999, when the new Ontario Mathematics Curriculum was introduced, there has been a simultaneous, but lesser-known focus on cross-curriculum literacy. This mandate requires that all subject specialists, including secondary mathematics teachers should teach their subject content and simultaneously support the development of literacy, which includes reading, writing, speaking, and listening. Clearly, such integration across disciplines requires specialized knowledge, tools and resources.

The findings of this study have implications for mathematics teachers who are attempting to achieve the goal of integrating reading strategies into their regular mathematics classroom. This thesis provides access to one teacher’s classroom-tested models and strategies. The description of Mr. Merle's practice includes possible reading strategies (i.e., vocabulary development, reading supplementary text, and reflection) and instructional recommendations about types of activities or specific literature titles to use and in what order and for what mathematics topics.

In addition, the findings of the study underscore that modified materials must match to as great a degree possible, the teacher’s practice, the expectations of the course and the needs of the students. Mr. Merle’s experience shows that integrating reading strategies requires a lot of energy and generated frustrations—a reality that any teacher needs to acknowledge before embarking on such an implementation plan. Mathematics teachers should not be afraid of running into some implementation obstacles since, according to Mr. Merle, any time spent on literacy strategies is worth the investment and will result in noticeable improvements (e.g., changing students' attitude toward mathematics by making mathematics concepts more relevant to them, and developing conceptual understanding of the mathematics knowledge rather than just reinforcing skills and
procedures). At the same time, the findings, because of the unexpected setting (i.e., a dedicated ESL program) may be relevant for mathematics teachers who teach in dedicated ESL programs or in schools with large immigrant populations. The MOE expects all teachers to support ESL students’ developing English proficiency. This thesis clearly illuminates one approach.

**Implications for Professional Development**

This thesis has implications for professional learning including pre-service and in-service teacher education programs. The findings of the study showed that mathematics teachers need appropriate support to implement reading strategies while teaching mathematics. According to Mr. Merle this support must not only provide an empirically-substantiated and discipline-targeted rationale for the importance of including reading in the classroom but also provide access to classroom-ready materials and resources.

To this end, Mr. Merle recommends that PD seminars be organized around opportunities for mathematics teachers to share the successes, challenges and resources from their experiences of trying to integrate reading into their classroom program, and then using recent empirical studies to shed light on both the benefits of integrating reading strategies in the mathematics classroom and the challenges inherent in such practice. Mr. Merle’s experience and practice may be an illuminative example—speaking personally and professionally to an audience of secondary mathematics educators.

**Implications for Educational Research**

This thesis contributes to a growing body of research related to the issue of teaching mathematics with a literacy focus. The findings and limitations of this research raise several possible questions for future consideration. Firstly, the short period of classroom observation did not permit the researcher to see students’ performance when reading supplementary text in pairs or individually which means that future research may be expanded in terms of examining both the
teacher's instruction and the students’ performance in this context. Secondly, this study presented a limited number of reading strategies and reading-based activities that did not include reading specific mathematics text, an area that is understudied but believed to be of enormous importance for student comprehension and mathematics achievement. Future research is needed to describe teachers’ practices in teaching skills specific to reading, decoding and comprehending mathematics text.

Furthermore, this study reports one mathematics teacher’s perspective about why mathematics teachers resist including reading strategies in their regular classroom and what kind of challenges they may face while implementing this innovation. Further research may explore the larger scale of mathematics teachers’ practice by focusing on how many secondary mathematics teachers in Ontario are actively involved in teaching reading in their classrooms; investigating what kinds of instruction and the range of resources are currently in use; and identifying in more general terms, the kinds of challenges and supports they experience around teaching reading in the context of the mathematics curriculum.

Based on the findings from this thesis, I am planning to investigate the above-mentioned considerations for my PhD research. Indeed, Mr. Merle’s experience made me think about the real picture of Ontario mathematics teachers’ practice with regards to teaching mathematics while simultaneously developing skills and strategies for reading literacy. Based on the gap between the intended curriculum goals and the implemented curriculum, as described provincially, using quantitative methods, I am planning to design a professional development course that provides education for teachers about reading strategies and provides field-tested resources for implementation and evaluation. The target audience will include classroom mathematics teachers, faculty instructors, and mathematics coordinators; thereby, contributing to the resources available for those wishing to integrate reading activities into the regular mathematics classroom.
Conclusions

This study examined one mathematics teacher’s practice of integrating reading in his classroom. In investigating this teacher’s experience, the influences that led to his passion, the practical challenges of integrating reading, one approach to explicit lesson organization, and actual lesson implementations were studied. This study is unique to the field of teaching mathematics because it describes an atypical mathematics teacher’s practice. The findings of the study provide concrete examples of designing lessons that embed the use of reading strategies to teach or inform mathematics concepts. The large number of ESL students in the observed class underscored the importance of integrating reading strategies in the mathematics context and, at the same time, presented possible ways to facilitate ESL students’ learning processes in mathematics.

The findings illustrate the benefits and challenges of integrating reading strategies from Mr. Merle’s experience. This thesis successfully answered the research questions that were identified at the beginning of the study. To this end, I described in detail how Mr. Merle developed reading literacy within the context of learning mathematics by presenting three reading strategies and possible implementation plans for the regular mathematics classroom. As well I shared Mr. Merle’s handouts and professional development resources for including both reading strategies and appropriate children's literature to complement and supplement required mathematics themes in Grade 9 Applied or Academic courses. In addition, this thesis reports Mr. Merle’s influences of including reading strategies in his classroom and the stumbling-blocks he faced in his attempts to integrate each of the reading strategies.

Unfortunately, the first goal of the study was not completely achieved because this teacher’s reading strategies were focused on helping students to comprehend supplementary text rather than specific mathematics text. Mr. Merle developed some specific reading skills which are necessary for comprehending mathematics text. The last question was expanded because of
Mr. Merle’s willingness to share information about both his practices and the challenges that are faced when integrating reading strategies. He also provided recommendations for how to change mathematics teachers’ attitudes toward teaching mathematics with reading literacy development.
REFERENCES


Ontario Ministry of Education. (2007a). *English Language Learners/ESL and ELD programs and services: Policies and procedures for Ontario elementary and secondary schools, Kindergarten to Grade 12*. Queen’s Printer.


APPENDIX A: INITIAL INTERVIEW PROTOCOL QUESTIONS

1. How long has reading mathematics been a component of your program? What inspired you to begin to include reading mathematics in your classroom?

2. Can you tell me the most significant impact of your efforts to include reading mathematics?

3. What do you think would be lost if you stop teaching students to read in your classroom?

4. Do you believe that there is widespread support for teaching reading in mathematics? Why? Why not? Do you think there is a widespread support for teaching reading mathematics?

5. What are the barriers you have faced in your efforts to include reading in mathematics class?

6. What would you say to the skeptic who believes reading has no place in the mathematics classroom?

7. What reactions did you get from your students and peers when you first began integrating reading into mathematics?

8. Can you describe recent lesson with reading teaching in your classroom?

9. How do you know which kinds of strategies you will use in this particular classroom?

10. How often do you use reading activities in mathematics classroom over the semester? What is the range of the activities you would typically use over semester?

11. What plans do you have for this semester with respect to reading in your mathematics classroom?

12. Can you tell me what mathematics topics in your opinion are most appropriate for teaching students to read mathematics text?

13. What kind of resources/literature do you regularly use to plan reading mathematics text?

14. What kind of role does the curriculum document play in developing lesson plans with reading mathematics text?

15. What do you think, how does mathematics curriculum support the idea of implementing reading mathematics? How does your current mathematics textbook support teaching reading?
### Strand 1: Measurement and Geometry (45% of course)

<table>
<thead>
<tr>
<th>Overall Expectation</th>
<th>Vocabulary Development</th>
<th>Supplementary Texts</th>
<th>Reflection</th>
</tr>
</thead>
</table>
| Solving problems involving perimeter, area, and volume | - Frayer Model (composite figure; Pythagorean Theorem)  
- Word Walls  
- word association  
- crossword puzzles  
- word search  
- cloze | - Major concept synthesis  
- Internet article “Prof breaks own record – for thrill of pi”  
- “Media Clips” (science of crowd counting)  
- Pappas’ *Mathematical Footprints* (Irrational number cover-up)  
- Bauer’s *Sticks* (jellybeans) | - K-L-W (area; Pythagorean Theorem)  
- post writing  
* calculate area of Norman Window;  
* how to develop volume formulas for rectangular prism, triangular prism, cylinder, cone)  
* # jellybeans in jar  
- Pappas’ *Mathematical Footprints* (Pythagorean Theorem – the Survivor) – teacher models  
- Homer Simpson assignment |
| Investigating the optimal values of measurements of rectangles | - Word Wall  
- crossword puzzle  
- word search | - Marilyn Burns’ book with tables | |
| Investigating and applying geometry relationships | - Word Wall  
- crossword puzzle  
- Frayer Model (co-interior angles)  
- cloze | - Bauer’s *Sticks* (pool table)  
* Pairs Read – instructions & manipulate using GSP  
- Burns’ *The Greedy Triangle*  
- EQAO practice material (reading map; locating fire)  
Pappas’ “Elementary Elements” | - photography assignment  
- Burns’ *The Greedy Triangle* – teacher models |
### Strand 2: Number Sense and Algebra (25% of course)

<table>
<thead>
<tr>
<th>Overall Expectation</th>
<th>Vocabulary Development</th>
<th>Supplementary Texts</th>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solving problems involving proportional reasoning</td>
<td>- Word Wall&lt;br&gt;- word association&lt;br&gt;- crossword puzzle&lt;br&gt;- word search&lt;br&gt;- Frayer Model (proportion)</td>
<td>- “Media Clips” (right handed and left handed people)&lt;br&gt;- newspaper flyers (unit rate)&lt;br&gt;- Schwartz’s <em>If You Hopped Like a Frog</em>&lt;br&gt;- Rowling’s <em>Harry Potter and the Sorcerer’s Stone</em></td>
<td>- K-L-W</td>
</tr>
<tr>
<td>Simplifying expressions and equations</td>
<td>- Word Wall&lt;br&gt;- Cloze&lt;br&gt;- Frayer Model (polynomials; equation)&lt;br&gt;- word association&lt;br&gt;- word search&lt;br&gt;- cross word puzzle</td>
<td>- <em>Silverstein’s Eighteen Flavors</em></td>
<td>- post writing&lt;br&gt;- K-L-W</td>
</tr>
</tbody>
</table>

### Strand 3: Linear Relations (30% of course)

<table>
<thead>
<tr>
<th>Overall Expectation</th>
<th>Vocabulary Development</th>
<th>Supplementary Texts</th>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using data management to investigate relationships</td>
<td>- Word Wall&lt;br&gt;- Cross word&lt;br&gt;- cloze&lt;br&gt;- Frayer Model (measure of central tendency)</td>
<td>- Stats Canada website&lt;br&gt;- Media Clips (“Notes from the underground”)&lt;br&gt;- Applying Linear Equations to Drinking and Driving</td>
<td>- K-L-W</td>
</tr>
<tr>
<td>Determining characteristics of linear relations</td>
<td>- Word Wall&lt;br&gt;- Frayer Model (First differences)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigating constant rate of change</td>
<td>- Word Wall&lt;br&gt;- Frayer Module (rate of change; direct variation)&lt;br&gt;- word search&lt;br&gt;- crossword puzzle</td>
<td>- Krull’s <em>Wilma Unlimited</em></td>
<td></td>
</tr>
<tr>
<td>Connecting various representations of linear relations and solving problems using the representations</td>
<td>- Word Wall</td>
<td>- Poe’s <em>The Tell Tale Heart</em>&lt;br&gt;- “Media Clips”&lt;br&gt;- Pairs Read: A/W 1999 text on height/time of Wonderland ride (p.7-9)</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C: STICKS: WORKSHEET

Name: _________________________

Part A: How Many Jelly beans are in the Fish Tank?

Mr. Merle will read a portion of chapter 7 from Joan Bauer's *Sticks*.

Mickey and Arlen use mathematics to determine the number of jelly beans in a fish tank to win a $100 gift certificate.

(a) They measure the dimensions of the fish tank:

Length = __________ inches  Width = __________ inches  Height = __________ inches

(b) They decide to “subtract a quarter inch from length, depth, and width for glass and bottom thickness” to account for the glass and bottom thickness. The dimensions are now:

Length = __________ inches  Width = __________ inches  Height = __________ inches

(c) Calculate the volume of the fish tank using the dimensions in part (b). Show all work.

(d) To determine the number of jelly beans in the fish tank, Arlen has “a perfect one-inch-square cube”. How many jelly beans do the boys determine are in a cubic inch? _______

(e) Knowing the volume of the fish tank and the number of jelly beans in a cubic inch, how many jelly beans should the boys guess are in the fish tank? Show all work.
Part B: How Many Jelly beans Are in a Pringles™ Can?

Mr. Merle has a Pringles™ can filled with jelly beans. How many jelly beans are there?

(a) Trace the circular base of the Pringles™ can in the space below.

(b) Mr. Merle will give you some jelly beans. How many jelly beans fit inside the circular base? ________

*Note: The jelly beans do not have to completely “fit each other”. For instance, look inside the Pringles™ can and notice that the jelly beans do not completely fill the container; that is, there are spaces or gaps between the jelly beans – some are “standing” while others are “lying flat”.*

(c) Estimate how many layers of jelly beans are in a Pringles™ can ________

(d) Determine how many jelly beans are in the Pringles™ can. Show all work.

(e) Suppose a classmate missed today’s lesson. Describe, step-by-step over the telephone, how you estimated the number of jelly beans in the Pringles can.

- Use correct mathematical language, notation, and vocabulary.
- Focus on clarity and provide a detailed explanation.
APPENDIX D: THE SCIENCE OF CROWD COUNTING: WORKSHEET

The Science of Crowd Counting

Your name: __________________________________________
Partner: _____________________________________________

• The following is a portion of a newspaper article that originally appeared in the October 28, 1996 *Toronto Star*.

• **Take turns** reading the newspaper article. Each student should **read alternate paragraphs**. Determine who will read the first paragraph and then take turns reading each new paragraph.

• If there is anything that does not make sense, **stop and have a discussion** before reading on.

• After you have finished reading the article, **summarize the main ideas** in the article.

The following questions are to be **completed on your own. Do NOT copy** what your partner has written. This is a hand-in assignment.

#1. After discussing with your partner the main ideas in the article, **write a summary**.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

#2. Describe how the Metro police estimated 108 000 people were at the rally.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

#3. Mr. Merle will assist the class in making a **square metre** on the floor using 4 metre sticks.

(a) 4 students are to stand in the square. Is this estimate for 100% reasonable? ________
(b) Mr. Merle will now ask 6 students to stand in the square. Is this estimate for 150% reasonable? 

[Recall that 4 people in the square gives 100%, so 50% more will mean 2 more people in the square, resulting in a total of 6 people.]

(c) “People sitting are judged to be at 25% density.” What is 25% of 4? 

#4. Using the number of square metres from Queen’s Park to College Street that the police measured, estimate the number of people at the rally with:

(a) 100% density

(b) 150% density
Complete a Frayer Model using the word...
APPENDIX F: TEXTBOOK FEATURES SCAVENGER HUNT: WORKSHEET

Textbook Features Scavenger Hunt

Your name: __________________________
Partner: ____________________________
Date: _______________________________

Use your textbook *Principles of Mathematics 9* to answer the following questions, which helps acquaint you to using your textbook. **Work with a partner.**

1. How many chapters are there in the textbook? ______
2. Using the **Table of Contents**, “Volume of a Cone” is in chapter _____, section _____ and begins on page ______.
3. On what page will you find the **answer** to question #5(d) for chapter 4, section 2? ______
4. How many sections are there in the **Measurement Relationships** chapter? ______
5. Turn to page 412. How many key **vocabulary** words are there for this chapter? ______
6. Turn to pages 8 and 9. What is meant by **Practise, Connect and Apply, Extend**? ______
7. Turn to page 12. At the side margin, there is a **Making Connections**. What is this? ______
8. Turn to page 35. What is meant by **Communicate Your Understanding**, with 3 questions labeled as C1, C2, and C3? ______
9. Turn to page 36. What is meant by **Literacy Connections**? ______
10. Turn to page 55. What is meant by **Did You Know**? ______
11. You want to determine where the Pythagorean Theorem appears in the textbook. Use the **Index** to find what pages deal with the Pythagorean Theorem. ______
12. At the bottom of page 370, there is **Key Concepts**. What is the purpose of this? ______
13. Use the **Glossary** section of the textbook to write the definition of the term “trapezoid”. ______
14. On what pages is the **Review** to the chapter named Analyse Linear Relations? ______
15. In what year is the textbook published? ______
Diagnostic Mathematics Assessment for ESL Students
Test Based on Selected Grade 8 Expectations
(Students who successfully complete this assessment should be placed in a Grade 9 math course)

Name: __________________________ Age: _______ Date: ____________

1. Evaluate:
   Example: \(2 + 5 - 3 = 4\)

   a) \(32 \div 8 + (27-19)\)  
   b) \(2.3 + 1.2 - 0.8\)  

   c) \(-5 + 3 - (-6)\)  
   d) \(\frac{3 + 7 \times 5}{20 - 1}\)  

   e) \(\frac{2}{3} - \frac{1}{5} \times \frac{5}{18}\)  
   f) \(\frac{8}{3} + (4)\)  

   g) \((-3) \times (-5) \times (-1)\)  
   h) \(8 + (-4)\)  

2. Find the square root.
   Example: \(\sqrt{9} = 3\)

   a) \(\sqrt{25}\)  
   b) \(\sqrt{16}\)

a) \( \frac{3}{4} + \frac{1}{4} = \)

b) \( 1 - \frac{2}{7} = \)

c) \( 4 \times \frac{2}{3} = \)

d) \( \frac{1}{2} + \frac{3}{4} = \)

4. Find the value of \( w \). \( w = ? \)

a) \( 5w + 12 = 27 \)

b) \( 7w - 12 = 8 + 3w \)

5. Fill in the blanks in the table below.

<table>
<thead>
<tr>
<th>Fractions</th>
<th>Decimals</th>
<th>Percents</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{1}{2} )</td>
<td>0.5</td>
<td>50%</td>
</tr>
<tr>
<td>( \frac{1}{4} )</td>
<td>0.1</td>
<td>12.5%</td>
</tr>
<tr>
<td>( \frac{1}{4} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Solve

(Example: \( 1 : 7 = 4 : 28 \))

a) \( 2 : 3 = 6 : \) __________

b) \( 3 = \frac{15}{5} \)

7. Complete the table below.

<table>
<thead>
<tr>
<th>Millimetres</th>
<th>Centimetres</th>
<th>Metres</th>
<th>Kilometres</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>82</td>
</tr>
</tbody>
</table>

158
8. Calculate.

Circles:  
\[
\text{Circumference} = 2\pi r \quad \text{(where "r" is radius and "\pi" = 3.14)} \\
\text{Area} = \pi r^2
\]

\[
\begin{array}{c}
5.8 \text{ cm} \\
\hline
\end{array}
\]
Diameter = 5.8 cm

Radius = __________

\[
\text{Circumference} = __________
\]

\[
\text{Area} = __________
\]

9. Calculate.

Triangular Prism:  
\[
\text{Volume} = \text{area of base} \times \text{height}
\]

\[
\begin{array}{c}
18 \text{ cm} \\
\hline
15 \text{ cm} \\
\hline
8 \text{ cm}
\end{array}
\]
Area of base = 60 cm²

a) Volume = __________

\[
\begin{array}{c}
10 \text{ cm} \\
\hline
5 \text{ cm} \\
\hline
12 \text{ cm}
\end{array}
\]

b) Volume = __________

\[
\text{Surface Area} = __________
\]
10. For each diagram, find the size of the missing angles. Explain your answer.

a) 
\[ \begin{array}{c}
\angle Y \quad 53° \\
\angle X \quad 74° \\
\end{array} \]

\[ \begin{array}{c}
x = \quad \\
y = \\
\end{array} \]

b) 
\[ \begin{array}{c}
\angle Y \quad 150° \\
\angle X \quad \\
\end{array} \]

\[ \begin{array}{c}
x = \quad \\
y = \\
\end{array} \]

c) 
\[ \begin{array}{c}
\angle Y \quad 60° \\
\angle X \quad 60° \\
\end{array} \]

\[ \begin{array}{c}
x = \quad \\
y = \\
\end{array} \]

11. An outcome is a possible result of an experiment. List the possible outcomes of the following.

a) \[ \text{A coin is tossed.} \]

b) \[ \text{A single die is rolled.} \]

c) \[ \text{The following spinner is spun.} \]
12. Study the triangles below and complete the chart.

a) Complete the chart below.

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>Height</th>
<th>Hypotenuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) What do you notice about the hypotenuse?

i. ______________________________________________________

ii. ____________________________________________________
13. Look at the pattern.

○○  ○○  ○○  ○○  ○○  ○○  ○○  ○○  ○○  ○○

a) Complete the table.

<table>
<thead>
<tr>
<th>Diagram #</th>
<th>Number of Rectangles</th>
<th>Total Number of Circles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) What is the pattern?

__________________________________________________________

__________________________________________________________

c) How many circles would there be when there are 10 rectangles?

__________________________________________________________

d) How many rectangles would there be when there are 300 circles?

__________________________________________________________
14. Complete the chart and graph.

<table>
<thead>
<tr>
<th>FAVOURITE SEASON</th>
<th>TALLY</th>
<th>FREQUENCY</th>
<th>PERCENT (%)</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>12</td>
<td>100%</td>
<td>360°</td>
<td></td>
</tr>
</tbody>
</table>

Recommended for: MPAI8D  
MPM1P  
FIP1P  
ESSENTIAL 9

Recommended by: ________________________________
Gr 9 Algebra

Across
2. when finding the power of a power, what do you do with the exponents?
3. a polynomial with 2 terms
5. a polynomial with 1 term
6. bottom number in a power
9. consists of coefficients and variables

10. algebraic expression consisting of terms
11. a letter used to represent a value that can change or vary
12. when dividing powers with the same base, what do you do the exponents?
14. 3x + 5 has how many terms?
Gr 9 Algebra

Down

1. made up of terms separated by plus and minus signs
4. short form to write repeated multiplication
7. make expression simpler or shorter
8. consists of a base and an exponent
13. the number in front of the variable
14. a polynomial with 3 terms
APPENDIX I: HOLES: WORKSHEET

Name___________________________________________

| Holes Worksheet |

Mr. Merle will read chapters 1, 2, and the beginning of 7 from the novel, *Holes* by Louis Sachar, copyright 1998, and published by Yearling (ISBN 0-440-41480-6). The book was awarded the John Newbery Medal for children’s literature. In 2003, a motion picture was shown at movie theatres.

#1. "The shovels were kept in a shed near the showers. They all looked the same to Stanley, although X-Ray had his own special shovel, which no one else was allowed to use. X-Ray claimed it was shorter than the others, but if it was, it was only by a fraction of an inch." (p. 27)

"The shovels were five feet long, from the tip of the steel blade to the end of the wooden shaft. Stanley’s hole would have to be as deep as his shovel, and he’d have to be able to lay the shovel flat across the bottom in any direction. That was why X-Ray wanted the shortest shovel." (p. 27)

(a) Each boy’s shovel (except X-Ray’s) is 5 feet long. Calculate the area of a circle with diameter of 5 feet. \([A = \pi r^2]\)

(b) Suppose X-Ray’s shovel is half-an-inch shorter (i.e., 4 feet, 11.5 inches or 4.96 feet) than the other boys’ shovel. Calculate the area of a circle with diameter of 4.96 feet.
[Note: 1 foot = 12 inches, so 11.5 inches is (11.5/12) feet = 0.96 feet]
(c) **Compare** the areas of the circles. Is having a slightly shorter shovel significant in the amount of dirt removed? **Explain** your thinking.

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#2. “You are to dig one hole each day, including Saturdays and Sundays. Each hole must be five feet deep, and five feet across in every direction. Your shovel is your measuring stick. Breakfast is served at 4:30.” (p. 13)

“Stanley walked to Zero’s hole and watched him measure it with his shovel. The top of his hole was a perfect circle, and the sides were smooth and steep. Not one dirt clod more than necessary had been removed from the earth.” (p. 37)

(a) Each hole is the shape of what 3-dimensional solid? _________________

(b) Determine the **volume** of a hole using a shovel that is 5 feet long. \[ V = \pi r^2 h \]

(c) Determine the **volume** of a hole that X-Ray digs with a shovel 4.96 feet long.
(d) **Compare** the volume of the holes. Is X-Ray’s slightly shorter shovel significant in the amount of dirt removed from the hole? **Explain** your thinking.

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(e) How much **less** dirt would X-Ray dig in 6 months? Show all work.
APPENDIX J: CROSSWORD PUZZLE: MEASUREMENT RELATIONSHIPS UNIT

Chapter 8: Measurement Relationships

ACROSS
4 Made up of 2 or more simple shapes
7 Number of triangles in a triangular-based pyramid
9 One third the volume of a rectangular prism is what 3-dimensional solid?
10 One third the volume of a cylinder is the volume of what 3-dimensional solid?
13 Longest side of a right triangle
14 Two thirds the volume of a cylinder is the volume of what 3-dimensional solid?

DOWN
1 Perimeter of a circle
2 Amount of material in a 3-dimensional solid
3 Square of the length of the hypotenuse equals the sum of the squares of the other two sides
4 Number of square units in a 2-dimensional figure
5 Number of triangles in a square-based pyramid
7 Half of the diameter
8 Distance around an object
9 Amount of space in a 3-dimensional solid
12 Volume of a triangular prism is area of the base multiplied by what?
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The Village of Round and Square Houses Worksheet

#1. Summarize, in a few sentences, the story that Mr. Mende read to you. Do not worry about grammar and spelling.

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#2. (a) Which house do you think will require the least amount of material to build? The men live in “Square” houses and the women live in “Round” houses.

(b) Give a reason to explain your choice.

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#3. Men live in "Square" houses.

(a) What is the shape of the 3-dimensional solid for the roof?

(b) What is the shape of the 3-dimensional solid for the walls?

(c) Calculate the surface area of the house. Hint: How many sides do you need materials for to build the house?


(a) What is the shape of the 3-dimensional solid for the roof?

(b) What is the shape of the 3-dimensional solid for the walls?

(c) Calculate the surface area of the house. Hint: How many sides do you need materials for to build the house?