Constructing and Assessing Individualized Secondary Mathematics Knowledge: A Case Study of Three Teachers using Laptop Computers

by

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A thesis submitted in conformity with the requirements for the degree of Master of Arts Department of Curriculum, Teaching and Learning Ontario Institute for Studies in Education of the University of Toronto

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Abstract

This study examines how secondary school mathematics teachers adapt their teaching 
practice to integrate the laptop into classroom instruction and how the implementation is 
effective in meeting the individual needs of students. A case study of three mathematics teachers 
at a co-educational, independent International Baccalaureate (IB) World School in Ontario was 
conducted.

Through interviews and classroom observation sessions, five major findings emerged: (1) 
reflection on improving teaching practice is necessary to successfully meet learning goals; (2) 
the teacher’s role is to facilitate the construction of knowledge; (3) the classroom is a rich 
learning environment where the students feel comfortable taking risks with technology and 
analyzing and discussing relevant real-world connections; (4) a variety of tasks and strategies 
must be employed to engage students interest, relate to their lives, elicit discussion and meet 
student ability and aptitude; and (5) laptops and/or tablets provide opportunities for the 
construction of knowledge.
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Chapter One: Introduction

1.1 Introduction

The purpose of this project is to determine how secondary school mathematics teachers can use laptops to facilitate curriculum delivery, in order to meet the individual needs of students. My choice of topic is based primarily on the fast-paced technological world in which I teach and learn. I have been privileged to grow up in a world that embraced technology; as a result, I feel capable of teaching in a laptop environment that strives to stimulate learning, daring my students to risk-take by utilizing the technology available at their fingertips to enhance their learning. This thesis is therefore an examination of how, in secondary school classrooms, teachers can create a laptop environment that supplements the student learning within the classroom walls and enhances it by meeting the individual needs of students. This chapter outlines the research context and questions, as well as the significance of these and my personal connection to the study. The plan of the thesis is also shared.

1.2 Research Context

The standards of the National Council of Teachers of Mathematics (NCTM, 2000) has six overarching themes, including technology, which is described as essential in teaching and learning mathematics because it influences the mathematics that is taught and enhances students’ learning. A learning environment that encourages secondary school math students to follow their curiosity, search beyond the classroom, into the virtual world, and seek assistance through multiple avenues is provided by technology. Computers are reshaping the way in which mathematics is taught and viewed in secondary schools. With the use of technology, students have the ability to delve deeper into topics, exploring them from numerous perspectives, manipulating variables, as well as making and testing conjectures. They can use their basic understanding of mathematical concepts and apply them to unfamiliar situations and contexts.
Today’s student population is made up of several types of learners. With laptop technology, students of varying academic ability and assessment needs can engage in tasks where access to a laptop can assist them through monitoring, concept attainment, progress updates, and leveled concept work that can be accomplished as successive levels are understood and attained.

There are a variety of goals when implementing technology in the mathematics classroom; three specific areas include problem-solving, critical thinking and promoting inquiry (Yerrick & Johnson, 2009). Teachers can create lessons based on global data available on the internet, showing real-life application, providing students an opportunity to use software to graph and analyze the data and come up with conclusions. Students are able to expand their understanding of concepts to unfamiliar situations and can inquire about topics that extend beyond classroom topics. Teachers report students are "more engaged learners" as a result of laptops and enjoy using multimedia applications, searching the Internet for instructional purposes, writing papers, and preparing presentations (Babell & Kay, 2010).

The purpose of using laptop technology in mathematics classrooms is to transform the lessons, resources and activities, thereby creating a new model for teaching and learning. With billions of websites, a multitude of digital resources, and a wide array of mathematical software, secondary school mathematics teachers have the crucial task of harnessing the available technology to enhance curriculum delivery.

A laptop classroom has the ability to set the bar for excellence in incorporating technology into the mathematics classroom. However, mistakenly, it is not about simply projecting a textbook onto a screen. It is necessary to understand that the laptop has software and can access resources from around the world that will enable teachers to provide specially
designed tasks and implement opportunities to differentiate instruction for students, thereby meeting each student’s individual needs, thereby helping to ensure the success of each student in the classroom.

Laptops are not just technological tools; rather they are cognitive tools that should be integrated into the teaching and learning of mathematics. Laptops enable attention to be given to individual students to meet their individualized needs. The "paradigm shift" resulting from laptop use fosters higher-order reasoning and critical analysis skills among students and greater teacher-student collaboration around instructional tasks (Weston, 2010). Students can use their laptops to be more organized, share information with classmates, and discuss strategies and approaches to different problems and learning situations.

1.3 Research Questions

This thesis focuses on the following research questions:

1. How can mathematics teachers adapt their teaching practice in order to integrate the laptop into daily mathematics instruction?

2. How does the implementation of laptops meet the individual needs of students?

I answer these questions by carrying out a detailed case study of the practices of three secondary school mathematics teachers as they apply their knowledge of mathematics, technology and find a way to merge these understandings to enhance student learning.

1.4 Significance of the Study

Today’s classrooms are morphing into new and unrecognizable arenas for learning, very unlike the ones today’s teachers were in when they were students. We are moving from the traditional, didactic model, where teachers gave information from the front of the classroom, to student-centered classrooms focusing on investigation, critical thinking and problem-based
learning. Teachers are required to adapt to these new environments and acquire new skills providing the best education for the students in their classrooms. This case study of three teachers is intended to give administrators’ and mathematics teachers’ insights into how to improve the quality of the curriculum delivery in today’s technological classrooms and enhance student learning by meeting individual needs. When adapting to fit into these drastically changing classrooms, teachers must pursue opportunities for professional learning and growth, in spite of obstacles such as budget and time constraints. Efforts include dialoguing with colleagues and others in the field to improve teaching practices, professional development opportunities in the form of workshops, seminars and webinars, and support within the school from other teachers, administrators and technology support staff.

The composition of students in today’s classroom is diverse; students come from different educational backgrounds, ability levels and learning styles. These factors necessitate that teachers be creative, resourceful, and employ a variety of effective teaching strategies to help support their students in the learning process. One of the latest strategies is the incorporation of technology in the classroom. However, it is not just about having a computer in the classroom or laptops in front of students. It is about the efficacy of teacher implementation in the classroom that will assist the students by matching their developmental levels, technological abilities and risk-taking capabilities to work with their strengths, adjust for their weaknesses, and meet their individual needs.

The findings of this study can be a resource to teachers looking to improve and enhance their teaching practices in a new technology-based world, especially in laptop environment. Details to help create student tasks specifically designed to use technology to enhance student learning and employing the pedagogy of technology in the mathematics classroom are invaluable
for teachers who are seeking to improve their teaching practice in a technology-based environment.

1.5 **Background of the Researcher**

My personal interest in this topic derives from my own goals and experiences as a mathematics teacher in a laptop-based school. As a secondary school mathematics teacher, I would like to find innovative and creative ways to improve my teaching practice. When I was a student, my mathematics teachers taught with traditional methods and though they worked well for me, I am aware that I need to adapt to the classroom that I teach in and the technology that my students have at their disposal.

As a student teacher, I was faced with some challenging students and classes; I had to design unconventional lessons, ones that would engage my students and still deliver the content. I used music, references to popular culture and games. If I expected my students to show up and participate in class, I knew I had to deliver the content differently than the usual, predictable, didactic lessons they were used to getting and ignoring.

My first professional teaching position was at an independent International Baccalaureate (IB) World School that adapts curriculum to encompass innovative technologies so as to provide each student with a strong education within a structured and supportive environment, where I continue to teach today. My initial teaching assignment was three sections of Grade 9 Middle Years Programme (MYP) Mathematics and two sections of IB Standard Level Mathematics. There were a number of challenges. I was using curriculum and textbooks that I had never seen before, the school had a high standard of academic excellence, and there was an expectation that teachers had to be efficient and adaptable to the use of technology. However, I knew that I had the pedagogical and technological skills to be successful.
To say that I was overwhelmed in my first year is an understatement. Countless hours were spent preparing lessons, creating worksheets, and carefully crafting real-life examples, while ensuring that my delivery incorporated as much technology as possible. The SMARTboard was a central component of my curriculum delivery, and my laptop was just the physical creation tool of these lessons. Though the SMARTboard is interactive, it still requires that a teacher work to make lessons that are creative, visually appealing and content driven, and in this task, innumerable hours can be spent.

Over the past seven years, I have had the opportunity to pilot several test projects, including the use of the SMART AirLiner (renamed the SMART Slate), a wireless slate, connecting to the laptop and projector, that permitted me to navigate the classroom and continue teaching, writing, and interacting with the content and the students. The major result of that pilot project was a segue toward our current classroom tablet-computer program.

For the past four years, the tablet-computer has become my greatest ally in the classroom. The tablet computer has made immense changes to the way that I teach, the way my students learn and the heights we are all capable of reaching. The tablet computer permits me to provide more effective note-taking and content delivery. The TI-SMARTview virtual calculator software for classroom involvement and the OneNote software helps with organizational skill development and answering student questions with full mathematical solutions sent via electronic mail.

Through this study, my desire is to extend the my current knowledge base and to incorporate some of the virtually limitless resources available to me, making it possible to differentiate tasks that will challenge various levels of student learning, but also provide avenues for accomplishment at all levels, thereby ensuring that my students all feel a sense of success.
1.6 Plan of the Thesis

There are five chapters in my thesis, intended to organize and describe the study in detail. Chapter One provides an overview of the thesis describing the research questions, background and significance of the study.

Chapter Two examines previous research conducted in this area. The Ten Dimensions of Mathematics Education (McDougall, 2004) is described as a conceptual framework for teaching improvement. Cooperative learning and differentiated instruction are explored to understand methods of enhancing student learning. Mathematics and Technology is discussed, delving into the multitude of opportunities for technology to be incorporated into the classroom through software and hardware enhancements. Finally, laptops in the mathematics classroom are discussed with respect to addressing the individual needs of today’s diverse student population.

Chapter Three describes the methods used to carry out the study. I outline the criteria that subjects needed to meet in order to be viable candidates for the study. I also discuss the data collection and analysis methods and the ethical considerations of the study.

In Chapter Four, I present the case studies of my participant teachers and explore the themes found in the qualitative data. Finally, in chapter Five, I answer the research questions and identify some suggestions for future research.
Chapter Two: Literature Review

2.1 Introduction

For teachers to embrace the implementation and integration of technology in their mathematics classrooms, they need guidance and assistance. Many pre-service teachers are excited by the prospect of using technology in their classrooms; however, when the time comes for them to apply their enthusiasm to the task of seamlessly assimilating technology into their lessons, they are often daunted and unable to put their ideals into practice (Campbell & Pargas, 2003).

Whether it is with youthful excitement or years of classroom experience, all teachers need to pursue professional development opportunities to understand who they are as educators in this new technological world, what technologies they are excited to use, and strategies to help them incorporate this learning into their classrooms to benefit their students.

The area of teacher development is vast and the use of an existing conceptual framework, such as the Ten Dimensions of Mathematics Education (McDougall, 2004), can help focus a teacher’s efforts with regard to improvement. Teachers must turn their attention to their changing role in the classroom and determine what strategies they can implement or supplement to enhance student learning. In this chapter, I will discuss current learning strategies as they apply to mathematics, types of technology available, and laptop programs.

2.2 The Ten Dimensions of Mathematics Education

The Ten Dimensions of Mathematics Education (McDougall, 2004) was chosen as the conceptual framework for this study. The framework was developed through multi-year research projects aimed at identifying areas of improvement in teaching given focused attention
(McDougall, Ross, & Ben Jaafar, 2006; McDougall, 2004; McDougall, 2007; McDougall & Fantilli, 2008; Ross, McDougall, & Hogaboam-Gray, 2002).

The first dimension is Program Scope and Planning, which focuses on the inclusion of all strands of mathematics in the classroom. This dimension encourages the use of mathematical processes along with the integration and connection of a variety of strands within a unit and/or lesson. Teachers are expected to use a variety of resources to strengthen their delivery of the curriculum.

The second dimension, Meeting Individual Needs, involves the use of different teaching techniques and strategies to address the needs of each individual in the classroom. According to this dimension, teachers should consider balancing lesson styles and using differentiated instruction techniques including: scaffolding, open-ended tasks, varying tools and time, and varying physical and grouping arrangements.

In the third dimension, Learning Environment, there are two themes to focus on. Teachers are asked to create cooperative groups for student work, while considering group size and composition with respect to their classroom organization, with the aim of creating a learning environment where both students and teachers reciprocate feedback.

The fourth dimension, Student Tasks, is the use of rich tasks within the mathematics classroom. Teachers should aim to make tasks engaging, using real-life contexts, and allow for students to choose from multiple representational forms, leading to increased student achievement.

The fifth dimension, Constructing Knowledge, urges teachers to use a variety of instructional strategies and to apply effective questioning techniques. Teachers should reflect on whether their questioning elicits mathematical thinking.
The sixth dimension, Communicating with Parents, requires teachers to acknowledge the power of family interaction and asks teachers to communicate about student performance, the mathematics program, and mathematics education with parents. Communication with parents can be in many forms and messages should be about content and performance, as well as giving parents strategies and tools regarding how to help their children learn and improve.

The seventh dimension, Manipulatives and Technology, is a key facet in the reform-based classroom. The regular and varied use of these tools can develop a better conceptual understanding of the material and encourages students to make connections through exploration.

The eighth dimension, Students’ Mathematical Communication, indicates that students should use both oral and written forms of communication to express their understanding and discover new ideas. Teachers should assign tasks that incorporate both methods of communication, as well as develop the skill level and efficacy of students in using each of the forms.

The ninth dimension, Assessment, explains that teachers should use diagnostic, formative and summative assessment to report on student achievement. Through their assessment, teachers should clearly express levels of student achievement, both in content and processes, and use a variety of assessment strategies.

The tenth and final dimension is the Teacher’s Attitude and Comfort with Mathematics. A teacher who shows a genuine interest in mathematics and values the importance of the subject will have increased success in sharing these beliefs with his/her students. Having a strong knowledge base and a secure comfort level with the subject allows the teachers to make more connections between concepts, fostering a deeper sense of inquiry and promoting student learning in mathematics.
The Ten Dimensions of Mathematics Education framework encourages teachers to focus on key areas that will generate higher levels of student achievement. Rather than a generalized approach to change, teachers are more effective at improving their teaching practices if they focus on one or two dimensions at a time. Recognizing that the dimensions naturally overlap, improvement in one area will inevitably advance other areas of their teaching as well. Utilizing the framework as a basis for change, mathematics teachers and administrators will get closer to meeting standards set out by the NCTM (2000).

The Ten Dimensions of Mathematics Education provides a variety of teaching tools to assist teachers in enhancing their teaching beliefs and practices. The Continuum (McDougall, 2004), along with the Attitudes and Practices for Teaching Math Survey (McDougall, 2004), can be used as self-assessment tools by teachers to determine which dimensions they should focus on to improve their teaching practice. For those who are unsure of how to use the continuum, a guide with further questions and discussion points is provided to make the Ten Dimensions more accessible. The Attitudes and Practices for Teaching Math Survey is a 20-question survey, which showcases the dimensions that the teacher may want to focus on as areas of improvement and also highlights their strengths as a teacher. In these tools, guiding questions are provided to prompt the teacher to consider key ideas within the chosen dimension and points for possible evidence are also provided to highlight what an exemplary teacher should be doing in their classroom.

Using the Ten Dimensions of Mathematics Education as a framework for teacher improvement is an effective way to increase student achievement. For my thesis, I have decided to focus on Dimension 2 – Meeting Individual Needs and examine how technology (Dimension
7), specifically laptops, is a promising teaching strategy that will address meeting individual student needs and provide opportunities to promote success.

2.3 Instructional Strategies

There are two prevailing methods of delivering curriculum. The first is the traditional method of teacher-centered, lecture style classrooms. Many of the teachers who stand at the front of the classroom today were once students in another teacher’s class. However, there are questions as to whether this method is conducive and effective with today’s youth.

In light of these questions, a second, more progressive method has emerged, which focuses on student-centered learning and is based on the idea that teachers are meant to facilitate that learning. Students are encouraged to experience and assimilate information in ways that will enable them to internalize their understanding of concepts (Willis & Mann, 2000). Ideally, this method provides students with knowledge that is of more value to them, since they have acquired it through their own initiatives.

The method that is utilized to deliver content depends entirely on the teacher and the teaching strategies that they choose to utilize. The methods used to deliver the subject matter of the curriculum are open to various forms of interpretation. Regardless of delivery, students must demonstrate understanding by “being able to carry out a variety of actions or performances with the topic by the ways of critical thinking: explaining, applying, generalizing, representing in new ways, making analogies and metaphors” (Alagic, 2003, p. 384). For this reason, teachers must work to create situations where students are given the opportunity to acquire knowledge as well as apply and explain their understanding.
2.3.1 Contextualized Problems

Students must learn to think intelligently in order to solve challenging problems (Willis & Mann, 2000). When students are actively engaged in problem solving, they are forced to move away from the traditional method of gathering, memorizing and regurgitating information. It is necessary for curricular instruction to be focused around problems that have “personal and social significance in the real world” (Beane, 1996, p. 11). This allows students the opportunity to work beyond theoretical concepts presented in textbooks and investigate a real-world situation using their “experiences and backgrounds as resources for learning in the classroom” (Civil, 2007, p. 2). Using contextualized problems in a mathematics classroom adds value to student learning, identifying a problem is real and cannot be ignored, resulting in relevant implications of their findings. Students appreciate that what they are learning has meaning and worth and that the outcomes of their learning have an impact on their own lives.

2.3.2 Critical Mathematics

Critical mathematics is defined by Gutstein (2007) to be education that can develop critical understanding and lead to critical action. First, on a technological level, students should be able to manipulate and present various sources of data as well as provide an interpretation of that data. This ability to problem-solve and apply one’s knowledge is essential to the world in which students will be living and working. Second, on a personal development level, students are encouraged to connect to the issue or topic. Finally, students are encouraged to move beyond just thinking about the problem and perform an action that would offer assistance. Tasks are designed by teachers to encourage a “think globally, act locally” mentality by helping students learn that wide scale, international realities can be changed by acting on a local level and providing assistance to those in need in their own communities.
2.3.3 Cooperative Learning

The National Council of Teachers of Mathematics (NCTM) has created a set of standards (2000) suggesting that teachers should create student-centered learning environments and tasks that engage students in “problem solving, modeling and constructively building conceptual understanding” (McClintock, O’Brien, & Jiang, 2005, p. 139). These engaging instructional programs stimulate students to communicate their mathematical thinking coherently and clearly to others, thereby solidifying the place for cooperative learning in the mathematics classroom.

Cooperative learning accommodates the diversity of learning styles within the classroom, combining the varied experiences and prior schema of the students, and forms a larger knowledge base from which the students can construct their knowledge (Schoenfeld, 1987) and maximize each other’s learning (Vaughan, 2002). When students collaborate to complete assigned tasks and understand concepts, it creates an environment where they can ask for assistance if content is found to be difficult for them as individual students (Paradis & Peverly, 2003).

The benefits of cooperative learning parallel Vygotsky’s (1978) zone of proximal development, displaying the difference between what an individual learner can accomplish on their own versus the level of success that can be obtained with assistance from others. Vygotsky (1978) believes that adults or a child’s peers can help their development and in our current world of constructivist, student-centered learning, teachers can use cooperative learning implement this idea in order to increase the understanding of mathematics.

2.3.4 Differentiated Instruction

Every child is unique and possesses individual needs that must be addressed to enable them to learn effectively. Classrooms consist of many students with a wide range of interests,
levels of readiness and diverse learning styles; therefore teachers should deliver curriculum through multiple strategies that meet the needs of auditory, visual and kinesthetic learners while still making the lessons interesting (Willis & Mann, 2000). Teachers strive to challenge the various levels of academic interest and ability in one class and work to assess them on these same abilities, ensuring that each student, regardless of ability, can excel in his/her own way and attain high achievement, irrespective of initial starting point (Willis & Mann, 2000).

Differentiated instruction is based on constructivist principles, whereby learning is approached and focused on a student-centered philosophy (Smith & Throne, 2007). Students are given multiple options for taking in content, processing and critically interpreting information, and finally expressing understanding through application. Some of the commonly used differentiated instruction techniques include: scaffolding, open-ended tasks, varying tools and time, and varying physical and grouping arrangements. The latest tool to be added to a teacher’s differentiated instruction repertoire is technology. Students are able to interact with software and other web-based programs to conduct research, assimilate and critically analyze data and communicate their findings with others (Smith & Throne, 2007). Technology is an essential differentiated instruction strategy in meeting the individual needs of mathematics students.

2.4 Mathematics and Technology

One of the most prominent and influential tools in today’s society is technology and it is therefore imperative that teachers incorporate new and exciting tools and strategies into existing curriculum to enhance students’ learning. Understanding the benefits of technology is vital, as students are now able to access large quantities of information, generate, process, and disseminate ideas rapidly, and have the ability to communicate with one another and their teachers with increased speed and frequency (Campbell & Pargas, 2003).
Technology has become a common sight in the classroom. Tools such as laptop computers, graphing display calculators and programs such as TI-84 Smartview, Graphmatica, Geometer’s Sketchpad, and Excel are considered as essential in the classroom as blackboards and paper (Smith & Throne, 2007). Given the significance of technology, it is important that educators find ways to incorporate technology into a classroom while still ensuring that independent and creative thought can be fostered in our students.

When children start elementary school, they are in inherently motivated to inquire and learn because the idea of going to school, learning original concepts and meeting new friends is stimulating. However, this motivation diminishes as they reach secondary school. This decrease in desire to learn happens because students become confined in the routine of a school day and participate in what they consider repetitive and boring activities. This disinterest is why many high school students decide that they will try to get by with as little effort as possible (Barkatsas et al., 2008).

One of the main goals of teaching is to engage students in activities in which they are intrinsically motivated. Each task is designed to assess students’ time on a given task, their risk-taking and persistence in the face of failure, as well as their creativity and comprehension upon reflection of the task (Smith & Throne, 2007). Technology is the added dimension that mathematics teachers strive to incorporate, breaking the routine, creating opportunities for internal motivation through relevant connections with real world applications.

Technology can take the form of an analysis tool for the purpose of learning and doing of mathematics. Without eliminating the requirement to think, technology can “assist students in their problem solving, support [the] exploration of mathematical concepts” (Barkatsas et al.,
2008, p. 286), and generally improve the quality of the planning, execution and reflection encompassed in each task.

2.4.1 Student Confidence and Ability to Learn with Technology

Today’s students have a firm grasp on the world of technology. Their world is one of cellular phones, electronic mail, digital organizers, social chat forums and websites that seem to increase exponentially. An average university student in one school year will perhaps read “8 books, 2300 web pages and 1281 Facebook profiles” (Wesch, 2007). A student will “write 42 pages for class” (Wesch, 2007) that particular semester but over “500 pages of e-mail” (Wesch, 2007). These kinds of informal statistics have led to discussions about how to utilize technology in the classroom to benefit student learning.

The overarching goal is to explore opportunities to apply this technological confidence for the purpose of learning. Opportunities exist in mathematics for young children to discover important mathematics ideas using technology. For example “computer games [are] regarded as powerful mathematical learning tools with great motivational appeal” (Lee, 2009, p. 530). Younger students are able to interact with technology and can do so in an environment that is entertaining and conducive to learning. More importantly, mathematical computer games are now being created that require information before beginning. A student’s ability or mathematical level and learning objectives for the game must be set prior to playing the game.

However, when thinking about high school students, a computer game may not be the best, and is certainly not the only, way to interact with technology. Older students are expected to have a good understanding of all of the software available to them, including mathematical software. Using a graphing display calculator, students can discover systematic effects of
modifications on various functions, and can learn to describe and classify them using terminology not normally associated with mathematics.

The process can then be reversed, with a student being presented with a graph and required to describe the equation of the given graph. They are expected to write all reports using Microsoft Word, and all mathematical equations must be imbedded in the document using Equation Editor. They are expected to create PowerPoint presentations, concept maps using Inspiration, and spreadsheets using Microsoft Excel. They can work through any number of programs and applets on the Internet, in Geometer’s Sketchpad and Graphmatica. These types of tasks that incorporate technology often extend beyond the routine mathematical problem-solving. In fact, the assessment tasks are often diverse and rich in content. The application of these technologies can “help students see the meaning and relevance of what they [have] learned and [help to] facilitate the transfer of contextual knowledge in authentic situations” (Lee, 2009, p. 530).

2.4.2 Teachers and Technology

In the reformed classroom, the role of the teacher is even more important than that of a traditional classroom. Dewey (1938) described teachers as “agents through which knowledge and skills are communicated and rules of conduct are enforced” (p. 18). He depicted a teacher-centered classroom where the information that the teacher is relaying is invaluable and the method of instruction is authoritative. However, Dewey makes it known that his opinion of the traditional form of teaching is not high and that he believed in a progressive form of education where students learn through experience. Now, teachers are seen to as guides, helping to navigate students in the discovery of knowledge, instead of solely being the knowledge provider and holders of information (Zack & Graves, 2001). Students are encouraged to formulate their
own understanding by linking new ideas to previous personal experiences without the imposition of constraints and interpretation by teachers. As guides, teachers remove themselves slightly, so that students can make critical and knowledgeable connections for themselves (Alagic, 2003).

A teacher’s creativity and flexibility enables the creation of a diverse range of learning opportunities for students. Using their knowledge as the basis of instruction, all teachers have a wide range of skills and strategies to facilitate student learning. However, in a technology-based classroom, teachers should not discount the potential to learn from and at the same time as their students (Zack & Graves, 2001). A seemingly simple student question frequently leads to a teachable moment that can deepen student understanding of the concept, widen a topic for future lessons, or create new avenues that can be pursued for learning.

Teachers can facilitate student thinking by encouraging dialogue (Alagic, 2003), by asking probing questions, and leading students to look for patterns (Reys et al., 1998). Discussions impress upon students the importance of the process and shift the focus away from only seeking a correct final answer. In traditional classrooms, students tend to focus on a methodical, algorithmic approach to problem solving, which discouraged students from risk-taking with other possible creative methodologies (Pape et al., 2003).

A teacher is an integral part in ensuring that a student is successful. By being cognizant of their facilitative role in the classroom, a teacher can create opportunities that foster effective learning.

2.5 Technology in Mathematics Education

The mathematics classroom is evolving daily with the introduction of technology. Mathematics teachers often feel daunted by the idea of effectively designing, implementing and
integrating technology into their lessons. The following are some of the technological tools that are available and are encouraged for teachers to use to enhance their classrooms:

2.5.1 Interactive Whiteboards (IWBs)

An interactive whiteboard (IWB) is a presentation device that is connected to a computer, enabling users to display and manipulate computer images on the digital projection screen. Users can control the software from the computer or directly from the board, using a pen or a highlighting tool to add notations or emphasize the intended object. All activities performed on the board can be saved and uploaded or printed out and distributed to the whole class. The appeal lies in the opportunity for use of dynamic, interactive images, animations, video and text that is visible to an entire classroom and that can also be controlled and manipulated by both the teacher and students. (Lee & Winzenried, 2009)

In order to ensure that the IWBs are used as a tool to support learning, teachers must be properly equipped not only with the technical capability to use IWBs, but also with a clear understanding of interactivity, active learning strategies, scaffolding of student learning, and the engagement facilitated in whole-class and small group instruction. Students will continue to play a passive role if teachers do not engage them in active, higher-order thinking processes through student-centered uses of these devices.

2.5.2 Classroom Response Systems (“Clickers”)

Classroom Response Systems, or commonly known as “clickers”, are given out to students, which allows teachers to pose questions and electronically collect responses from individual students. At first glance, clickers may seem to function only for fairly low-level, factual learning. However, they are increasingly being linked with higher-order, inquiry-based learning; for example, teachers can create critical questions that require students to assimilate
information they have learned and apply their understanding, or perform calculations before selecting their answer.

2.5.3 Simulations

Simulations are animated, interactive, game-like environments that emulate real-world phenomena. Students are encouraged to explore these environments through engagement with the objects and situations they encounter.

2.5.4 Graphing Display Calculators (GDCs)

The National Council for Teachers of Mathematics (NCTM) credited the graphing calculator for “the emergence of a new classroom dynamic in which teachers and students become natural partners in developing mathematics ideas and solving mathematical problems,” especially in algebra and higher mathematics.

In general, the literature suggests that the use of calculators improves learning in three areas: the understanding of graphical concepts, the ability to make meaningful connections between functions and their graph, and enhanced spatial skills. Calculators help to improve students’ operational and problem-solving skills and are becoming an integral part of testing and instruction.

2.5.5 Computer Assisted Instruction (CAI)

Computer Assisted instruction (CAI) is defined as software or websites where instruction or remediation is presented via a computer.

2.5.5.1 Wiki

A wiki is a website that allows the collaboration by multiple users to create and edit any number of interlinked web pages via a web browser. The main purpose of a wiki is to promote
topic associations between different pages, enable easy content access, modification and enhancement through various participating editors.

2.5.5.2 Geometer’s Sketchpad (GSP)

Geometer's Sketchpad is a commercial, interactive, geometry software program that gives students a tangible and visual way to learn mathematics, increasing their engagement, understanding, and achievement. The software is not just for geometry, but can be also be used for algebra, calculus, and other areas of mathematics. To supplement the software program, there is also an online Learning Center, which provides videos, tutorials, tip sheets, and additional resources to help both teachers and students quickly learn the software.

2.5.5.3 YouTube and TeacherTube

YouTube and TeacherTube are video-sharing websites on which users can upload, share, and view videos. Teachers can create accounts that hold creative visuals, video projects and virtual lessons, which can be accessed any time by a teacher’s own students as well as other teachers and students around the world, in search of imaginative new teaching strategies, stimulating examples, and artistic interpretations of mathematical concepts.

2.6 Laptops in the Mathematics Classroom

With the ever decreasing cost and size of laptops, more schools are opting to use them in classroom learning, wherein each student and teacher has a personal laptop computer, typically with wireless access. Successful laptop programs must be part of balanced, comprehensive initiatives that focus on education goals, curricula, teacher professional development, and student assessment practices.

There are four key requirements that must be met to promote the implementation and subsequent success of a laptop program in secondary schools: professional development,
technology support, access to technological resources, and curriculum coordination time (Gorder, 2008).

2.6.1 Professional Development

In addition to adopting new teaching strategies and initiatives, teachers must be provided with opportunities to participate in an extended process of professional development. Teachers need time to acquire technology skills and develop new teaching strategies for integrating technology into the classroom.

Academic administrators are encouraged to incorporate technology training for faculty into the academic timetable and school year to maximize its impact (Gorder, 2008). Technology training workshops should be flexible, because teachers learn at different rates and have individual needs when mastering new skills, and consist of a comprehensive variety of skills to address teacher individual needs and skills (Gahala, 2001). In this way, teachers can attend sessions that apply to them, regarding their level of competence or benefit their area of academic expertise. During these workshops, teachers should be able to spend time working with different software and tools (Foley, 2003), to increase their comfort in using these tools, finding connections between the tools and their lessons, reaffirming the use of technology in their classrooms, and also to receive immediate feedback and support from the technology trainer. Professional development time is especially important when teachers are learning new technology skills:

This time for learning is especially important as schools incorporate information and multimedia technologies into the classroom. When a school proposes to install these technologies, each teacher must become adept at their use, identify appropriate hardware and software for his or her subject matter and students, and sit down to work on the computer. Learning to use new technologies well is accomplished best when teachers have time available to learn in a variety of ways. Teachers need large blocks of time to gain initial familiarity with new hardware or software, learning and practicing for sustained periods. Time to observe an experienced user model an application in his or her
classroom, time to design a new hypermedia stack, or time for group reflection on a recently tried application—all recommended approaches to professional development—should be made available every day. (Renyi, 1996, p. 12)

2.6.2 Technology Support

Individualized or team support is essential to ensure the successful integration of technology in classrooms (Foyle, 2003). The integration of technology in classroom has failed to be successful due to equipment failure, software complexity and data loss, or embarrassment and frustration of teachers. When teachers are trying to use technology in their classrooms and they encounter difficulties, they need immediate help and support. If technical problems arise frequently and teachers find themselves waiting for issues to be resolved, there will be increased tendency for teachers to abandon their efforts to incorporate technology into their classrooms (Gahala, 2001).

In schools that are implementing laptop programs, infrastructure repair or upgrades must be responsive and timely. Frequent occurrences of server breakdowns, printer jams, or insufficient computer memory will disrupt instructional and administrative activities and may undermine the entire technology program. Therefore, a designated and highly specialized technology support team is essential to the implementation and success of a laptop program.

2.6.3 Access to Technological Resources

One barrier to technology integration is the difficulty many teachers face in finding and using appropriate software for instruction. Teachers may need guidance in locating multimedia software and Internet sites to support the subject curriculum and the school's learning goals (Gahala, 2001). While the volume of available curriculum materials has increased due to the World Wide Web, locating high-quality material and using it effectively to create innovative learning opportunities for all students remains a fundamental challenge for teachers.
A second barrier is selection of and access to laptop software. When schools implement laptop programs, it is sometimes difficult to pre-determine the needs of teachers and subject areas. As a result, too little or too much software is acquired and installed. As a laptop program continues to evolve, teachers should be involved in the software selection process, to offer opinions on appropriate software for instruction and create opportunities to incorporate specific software into desired subject areas (Gahali, 2001).

2.6.4 Curriculum Integration

Successful implementation of a laptop program requires more than technological equipment and a few lessons on how to use software. According to Bandura (2000), “the task of creating productive learning environments rests heavily on the talents and perceived efficacy of teachers” (p. 4). Teachers will spend a significant amount of time creating and preparing effective technology-based lessons, regardless of whether they have taught the course before, or are using a pre-existing lesson they have created. A good teacher will spend time walking through the lesson just as their students would, to increase their familiarity with the process and predicting possible challenges for students, ensuring that the lesson is student-centered and build upon a student’s prior knowledge, while maintaining the pedagogical standards that ought not be lost with the addition of technology (Edwards, 2003).

Just as with all new initiatives implemented in schools, teachers need to combine the curricular connections with the technology to ensure successful integration takes place. Administration need to consider blocking scheduled time to encourage teaching partners to collaborate, enabling the sharing of ideas, the creation of curricular tasks enhanced by technology, and the ability to uphold the delivery of the curriculum (Gorder, 2008).
2.7 Teacher Changes through the Use of Laptops

Technology is not transformative on its own; instead, as with all tools, it is the effective use of technology by teachers that will engage students. The use of laptops can promote meaningful, engaged learning by allowing students to work on authentic, meaningful, and challenging problems, to interact with data in ways that allow student-directed learning, to build knowledge collaboratively, and to use higher-order thinking skills (Smith & Throne, 2007). However, this type of effective integration of laptops in the mathematics classroom can be a daunting task for teacher (Campbell & Pargas, 2003).

In order to help teachers in this process, Jaffee (1997) has outlined four pedagogical principles, which help to demonstrate technology integration: active learning, mediation, collaboration and interactivity. Active learning using technology is defined as student interaction with the content, allowing knowledge building and construction (Gorder, 2008). Teachers can create avenues for active learning using technology by engaging students and focusing their attention on activities that require understanding information gathered from multiple sources, discerning what is reasonable, and applying these skills to different contexts.

Schroeder (1993) believes that technology provides a mechanism by which deeper interactions can occur between a teacher and his/her students. Technology helps to meet the needs of separate students through individualized tasks and requirements, creating opportunities for teachers to use this information for further discussion and assessment. With the introduction of computers, classrooms have become more student-centered than ever; the teacher’s role changes from that of an expert lecturer to a facilitator of collaboration (Gorder, 2008), helping students both learn from and teach one another.
Alley and Jansak (2001) state that the best approach for a teacher to prepare themselves for unfamiliar strategies is to translate and incorporate them into teaching practice. Implementation of technology-based methods requires teachers to embrace new methodologies and find creative opportunities to promote learning. Interacting with technology creates opportunities for mathematics students to gather content customized to meet individual needs to assessments of tiered degrees of difficulty.

As teachers move toward integrating technology into mathematics classrooms, they assist students in building lifelong learning skills, as well as critical thinking skills that will continue to aid them beyond the walls of the classroom (Westhaven, 2003).

2.8 Meeting Individual Student Needs with Laptops

The use of technology is transferrable for many types of learners. Given its accessible nature in a laptop classroom, many at-risk learners who would otherwise be struggling can benefit from the use of technology.

With the aid of laptops, teachers can create scaffold lessons that guide the development of student understanding. With the use of various mathematics programs on the laptop, teachers are able to guide their students through the lesson with interactive activities, visual models, graphics, and videos promoting, student exploration and discovery.

The use of technology enriches the learning of average ability leveled students and helps lower-level students develop their understanding through modifications to the lesson, specifically identified for their learning style. Students using laptops can replay videos for clarification and attempt multiple problems of the same style before progressing to the next level of difficulty. For higher-level students, technology provides avenues for enrichment and extension. Students,
irrespective of their mathematical ability, will find aspects of laptop use that they will gravitate toward.

2.9 Summary

Research shows that it is possible to implement learning through the use of laptops in the mathematics classroom, and that it provides benefits to students’ learning by meeting individual needs. The NCTM standards encourage teachers to promote a constructivist, student-centered, cooperative learning environment, utilizing instructional strategies such as differentiated instruction, so that students are able to construct their own knowledge. Incorporating technology in the form of laptop use can provide opportunities for effective and long-term learning through tiered lessons, problem-solving, and modeling based on learning style, fostering deeper levels of understanding. Although challenges exist when implementing laptop technology in the classroom, teachers need to drive themselves to enhance their teaching practices by seeking out professional development opportunities, collaborating with other teachers and creating laptop lessons that create an environment where cooperative strategies can flourish.
Chapter Three: Methodology

3.1 Introduction

In this thesis, I discuss the insights of three secondary school mathematics teachers as they divulge the modifications they incorporated and the options they discarded from their respective teaching practices while using laptop computers in their classroom. Each of them wanted to meet the mandate to incorporate laptop technology in their mathematics classrooms, while addressing the individual needs of their students to ensure their success in mathematics. This chapter discusses the research context, the methods of data collection and analysis and the ethical considerations of the study.

3.2 Research context

I used a qualitative approach (Glaser & Strauss, 1967) to explore “naturally occurring, ordinary events in natural settings” (Miles & Huberman, 1994, p. 10) and to gain a better understanding of the phenomenon of knowledge construction in the mathematics classroom. The study was conducted to determine both how an educator constructs knowledge as well as the reasons why an educator would do so.

I focused on secondary school mathematics teachers and the teaching practices and strategies that they use in a laptop environment to foster successful mathematics learning. The purpose of a case study is to carry out a deep investigation and analysis of a single entity where multiple factors can be explored (Flyvbjerg, 2006; Merriam, 1988; Smith, 1978; Stake, 1995). The study is an observational case study where “the major data-gathering technique is participant observation and the focus of the study is on a particular organization” (Bogdan & Biklen, 1992, p. 63). Instead of selecting the school as the organization of study, my thesis investigates the
teacher participants and the focus of the case studies is to determine how these specific participants address the individual needs of mathematics students in a laptop environment.

3.3 Participant Recruitment

The acquisition of the three participants of this study will be discussed in detail. There were several criteria that subjects needed to meet in order to be viable candidates for my study:

1. Subject must work with laptop computers (or tablet computers) on a daily basis in the classroom.
2. Subject must be working in the 1:1 laptop computer environment for at least one year (i.e. a teacher in his/her first year of teaching or working in a laptop environment is not a viable candidate).
3. Subject must have a desire for his or her students to improve in the learning of mathematics.
4. Subject must believe that laptop computers provide an opportunity to address the individual students in a way that was not possible prior to their introduction in the classroom.
5. Subject must be open to being observed for the purposes of the study and not for evaluation purposes.

As I began my thesis research, I decided to focus my attention on information that would help draw out possible subjects and also assist in narrowing down the field of research. I contemplated how teachers often participate in professional development sessions and are disappointed with the presenter, the presentation or the outcome of the day. This past year, the administration at my school decided to do something unconventional and actually ask our own faculty members to facilitate professional development sessions. Almost immediately, everyone
was more involved, more engaged, and had much more to gain, as these were our own colleagues sharing their knowledge or disseminating information from other notable sources. The shift in the faculty presence and participation in the professional development sessions was noticeable.

As I continued to take into consideration various participants as a focus for my thesis, I found that my current work environment proved to be my source of inspiration and inquiry. Currently, I work in a 1:1 laptop and technology-based school. My colleagues knew about my quest for my Master’s degree and often enquired about how my thesis writing was progressing. The moment that one of them offered to help with my research, I realized the connection between the professional development sessions and my thesis research and, with much excitement, that my own colleagues would be excellent sources of data.

Using the participant recruitment criteria outlined above, five potential colleagues fulfilled the necessary requirements. Of the five possible subjects for study, I chose three who had schedules that worked in tandem with mine. This provided convenient opportunities for me to interview them and attend their classes, in order to observe their teaching methods and laptop/tablet instruction, without causing disruption to their workload.

3.4 Data Collection

A series of interviews and observation sessions were conducted to further examine emerging themes uncovered from the data. Initial interviews were more general in nature whereas subsequent and final interviews asked more detailed questions, specific to the area of study and relevant to the emerging themes. From the data collected, I have discovered commonalities that have guided my findings to determine how teachers can facilitate a laptop environment where individual student needs are addressed.
Data collection for the study took place in three different ways: a survey, interviews and in-class observations. The data was collected between February 2012 and June 2012 and arrangements to meet with the individual participants were scheduled based on their respective availability.

Prior to beginning the study, each participant signed a letter of consent (Appendix A) acknowledging their involvement as well as their time commitment to the study. Next, each participant took an Attitudes and Practices for Teaching Math (McDougall, 2004) survey which asked questions about the teacher’s current attitudes and practices about mathematics education (Appendix B). The twenty-question survey gave the participants quantitative data regarding his or her alignment to reform-based teaching qualities categorized by dimension.

This study focuses on the second dimension, namely Meeting Individual Needs, which involves the use of different teaching techniques and strategies to address the needs of each individual in the classroom. Each participating teacher understood that this was the dimension of focus.

The first meetings occurred between April 2nd and April 5th, 2012. Each meeting consisted of an initial interview with a participant to determine his or her thoughts about success in the classroom and the goals for their students. Questions were also asked to find out more about the background of the teacher, the school’s culture, challenges that he or she faced as an educator and general opinions about mathematics education (Appendix C).

Classroom observations were made three times a month for three months. Prior to the lesson, each participant was asked what his or her plan was for the lesson and what strategies they hoped to incorporate in the lesson. In this way, I could ensure that the teachers were considering the second dimension, meeting the individual needs of students, as they worked
through their lesson plan. I would ask the teacher what they were to look for during the lesson, what strategies would be employed, and find out more information about the lesson that was to be taught (Appendix H).

During the teaching time, I would sit in on the lesson and take notes on the teaching strategies implemented and student responses to the methods used. The observation template also had key ideas for the observer to look for, corresponding with the specific dimension chosen by the teacher. The teachers could also make additional notes if they wished.

Subsequently, the teacher and I would have a meeting to debrief the lesson. I would state my observations and answer any questions posed by the teacher regarding clarification or further explanation of the classroom experience. The teacher was encouraged to share their ideas about the lesson, comment on what they felt went well and what they would like to focus on for the next session. If asked, I would share suggestions of what the teacher could change for the next classroom observation.

A final informal interview was carried out with each participating teacher to gather more data about what they learned from the process and their focus on meeting the individual needs of students (Appendix I). All interviews were audio recorded and peer coaching sessions and classroom observations were recorded using hand-written field notes.

3.5 Data Analysis

All interview session recordings were transcribed and the transcripts were reviewed against the recordings to ensure accuracy. This study used a case study approach (Stake, 1995). The data analysis followed a series of coding cycles. For this study, an open coding format was used where data was examined, compared and categorized (Strauss & Corbin, 1990).
In the open coding process, the first step involved the reading of transcripts and key ideas were highlighted. These key ideas were labeled in order to make the data more manageable. Next, these smaller data snippets which Glaser and Strauss (1967) refer to as concepts were grouped by similarity to form sub-categories. The sub-categories were re-grouped by similarity and labeled as categories (Strauss & Corbin, 1990). The categories are the over-arching themes extracted from the data.

Three themes were found: technology, student engagement and meeting individual needs. The data collected proved to be the source of the major findings of the study, however, categories were created with components of existing literature in mind to be able to generate a possible hypothesis which could be relevant to current research and practices (Glaser & Strauss, 1967).

3.6 Ethical Considerations

Participants first verbally agreed to be part of this study and were sent an e-mail (Appendix D) to inform them of the details of the study and the participant commitment required. The participants were selected for their enthusiasm for the project and their willingness to collaborate, participate, share their experiences and spend time with the project. Each participant then signed a formal letter of consent (Appendix A) to confirm his or her participation. It was stressed to the participants that they could participate as much or as little as they wanted and could stop at any time. Participants were reminded that pseudonyms would be used and all interviews would be confidential. Specific details about the location of the school involved in the case study have been omitted.

The Head of School was also given a letter (Appendix G) that contained information about the study, the purpose of the study, what it entailed and what the teachers participating had
committed to being involved in. This letter was also signed, giving formal consent for the study to take place in the school.

An e-mail (Appendix E) was sent to parents in the school who had children in classrooms where observations were being conducted to inform them of the purpose of the study as well as the indirect participation of their child. Students in observed classes were informed of what was taking place (Appendix F) and that I would be taking notes on the teaching strategies and the student responses to the methods being implemented.
Chapter 4: Findings

4.1 Introduction

In this thesis, I explore how the use of laptop and/or tablet computers enables secondary school mathematics teachers to meet the individual needs of students. Using the participant recruitment criteria previously outlined, I decided on three teachers who successfully fulfilled the conditions and who subsequently consented to being participants in the study. In examining the data from Brad, Keith, and Sheila, three themes emerged from the data analysis: technology, student engagement and meeting individual needs.

4.2 School Context

The school where Brad, Keith and Sheila work is a co-educational, independent, International Baccalaureate (IB) World School that is home to approximately 80 teaching faculty and just over 600 students from Junior Kindergarten to grade 12. With the desire to be one of the leading schools in innovation and technology, the faculty are encourage to adapt curriculum to encompass innovative technologies so as to provide each student with a strong education within a structured and supportive environment.

The laptop programme piloted at the school in the year 2000 and is currently in its thirteenth year of implementation. In 2000, the school was still in the early stages of expansion to include a secondary school program, with all the associated space constrictions, and classes were competing for computer time in the two available labs. When a founding administrator returned from a visit to another laptop school in Maine, the excitement and possibility of enhancing the teaching and learning environment prompted the transition to a technology-based learning environment that included laptops for all students, SMART Boards, online collaboration tools, the latest learning software and a wireless environment. Now, laptops and/or tablets are used
across the curriculum on a daily basis; the computer is the student’s notebook, textbook and, communication tool.

Teachers work in a wireless laptop/tablet setting where technology is integrated into the learning environment, enhancing content delivery and facilitating learning, communication and collaboration. They are encouraged to seek out and embed innovative strategies, emerging technologies, and online resources to design curriculum that incorporates interactive activities, lessons, and evaluations that encourage student involvement and success. As teachers working in this IB World School, the participants have very high standards to meet, as well as many opportunities for growth in their roles as mathematics educators.

Given space constraints at the school, classrooms are not designated as math only classrooms. Therefore, for the middle school students, teachers go to the homerooms, where students spend the majority of the day except for specialty subject such as science (designated middle school science lab) or the arts (visual arts room, drama room and music rooms). In the senior school, teachers teach mathematics in classrooms that are available in the timetable. In the past, an attempt has been made to have certain rooms designated for mathematics; however, other subjects continue to share the space and classrooms therefore have a mixture of subject material covering the walls. Obviously, this does not create the desired “feel” for a math classroom, but the three teachers work with the other teachers in the school to bring math into as many of the classrooms as possible.

Brad, Keith and Sheila are all very conscious of the environment in which their students are learning. Each of them attempts to ensure that their students gain the most from the structure of not only the classroom setup, but also the role that each of them plays as the teacher within it and the technological resources that they have access to.
4.3 Case Studies

The following section discusses each of the teacher-participants and their responses to the three themes. These responses were taken from the survey and teacher interviews or were witnessed during classroom visits.

4.3.1 Brad

Brad has been teaching for 14 years. He explained that his initial plan for a career in the health science profession did not work out. He traveled and ended up working in outdoor and experiential education, which prompted his decision to enter the teaching profession. Brad is an inspiring teacher who stated that:

[His] ultimate goal in math is how to better reach kids who struggle in math. [He is] looking for resources to support [him] in better understanding developmentally how kids learn in math, common misconceptions and errors that kids develop, how to better address them and correct them. [Overall, it is in an effort] to isolate and define where kids struggle. (Interview, Tuesday April 3, 2012)

He wants to have students who want to learn; “So whether that is through inquiry, research, how to take your basic curiosity and questioning about the world, issues in the world, and how to investigate that so that they feel some satisfaction and better understanding” (Teacher Interview, Tuesday April 3, 2012).

When overviewing Brad’s results to the Attitudes and Practices to Teaching Math Survey (Appendix B, March 5, 2012), I noted that he obtained an overall score of 5.526. The higher the score out of six, the more likely the teacher is engaged in reform-like mathematics teaching practice. Specifically, Brad scored a six in two dimensions – Learning Environment and Manipulatives and Technology. However, he scored consistently high in all of the dimensions. Brad aims to use curiosity, inquiry, and technology to promote learning in his mathematics classroom.
4.3.1.1 Technology

Brad described his incorporation of technology as follows:

I slowly started integrating it last year giving kids the option of doing their homework on the tablet. This year, the incorporation and use of Microsoft OneNote has been huge. That has been a change for me from doing lessons and activities on SMART Notebook where I almost used it as an interactive PowerPoint forum. Now with OneNote, I’m trying to use its organization, to be able to migrate components such as notes, homework, activities, etc., into student notebooks and provide extensions and answer keys so that it becomes a one-stop shop is one of the aspects. The use of interactive websites to consolidate some of their understanding is part of it, and Blackboard, as a filing cabinet to make things available to them. There is more I would like to do with technology, but that’s a time thing and [about] understanding best practice. (Teacher Interview, Tuesday April 3, 2012)

Brad’s use of technology in the mathematics classroom is based on helping students understand mathematics. Brad feels that he must understand why and how something will help him or make learning better before he utilizes it.

For example, Brad was introduced to OneNote two years before implementing it in his own classroom. He initially did not see the purpose of changing from his use of SMART Notebook. However, after attending a three-day workshop dedicated solely to the use of OneNote, Brad came back to the school ready to tout the use of it in all subject areas. Brad appreciates the ability to create virtual binders, thereby eliminating the use of paper in his classroom aside from assessments, which he saw as an opportunity to assist in the organization of notes, homework and classes. For his younger students, he was able to create each unit and upload it to their OneNote binders virtually, through the school network. This enabled students to see how a binder should look and how they should work toward organizing their mathematics in the future.

Using OneNote, Brad models note-taking strategies – from highlighting key points, underlining word problem facts, or using icons to denote important information. He also models homework strategies – using lined or graph paper, checking homework and using icons to denote
areas of difficulty or challenge. Brad can model the use of virtual graphic organizers promoting collaborative work and can encourage their use by embedding templates into a student’s OneNote binder.

Brad embeds websites and videos so that students can watch or experience alternate explanations to the ones given in class. He encouraged the use of audio and video recording at the end of the unit of study so that students could comment directly into their OneNote journal about their preparation and study habits for the test, aspects of the test they struggled with or achieved success in. This audio or video alternative to writing a response has been a useful and refreshing change to assessment and particularly to reflection. Brad quickly became a champion of OneNote, but only once he saw and understood for himself just how useful it was to his students’ learning.

Brad also utilizes an online resource for practicing math called IXL Learning (www.ixl.com). Once again, Brad had to experiment with the resource himself to appreciate its value. He then explained to his fellow department members how the resource would be effective in the mathematics classroom. Brad created five online classes in the interactive learning environment and enrolled his students according to his class roster. Brad then assigned skills for his students to practice that related to the day’s lesson. He believes that the students should receive instantaneous feedback. If they produced the correct answer, their score advances on the right hand side of the screen. This score indicates their level of comfort and grasp of the concept. If, however, the student answers incorrectly, they are provided with a full explanation as to how to approach the question in the future. Some students have taken to screen capturing this information and creating an information sheet of areas of difficulty, to help them study prior to tests.
In addition to using software that will aid in student note-taking and organization and online resources aimed at capturing interactive teachable moments, Brad’s use of technology shows that he must see the intrinsic value of the use of software before he encourages its use among his students.

4.3.1.2 Student Engagement

Brad is very interested in “whether the student is engaged in the classroom setting” (Teacher Interview, Tuesday April 3, 2012). He is looking to see if the “student is participating and engaging with their peers” but also if they are “seeking assistance from the teacher and participating on IXL” (Teacher Interview, Tuesday April 3, 2012).

On the understanding that a student needs to be engaged in order to learn, Brad also recognizes that attracting and maintaining the attention of his students requires a good understanding of the social, emotional and behavioural attitudes of teenagers. “A student’s energy level and willingness to learn fluctuates during the day. What [a teacher] can do at 9:20 is very different [than] at 2:15 and what [a teacher] can do just prior to lunch” (Teacher Interview, Tuesday April 3, 2012).

While attempting to facilitate learning in an environment made up of teenagers, Brad “plans out activities in lessons where kids can be given greater amount of time to explore difficult concepts” (Teacher Interview, Tuesday April 3, 2012). Brad’s concept of student engagement is steeped in the idea of constructing knowledge by working through problems, giving students time to puzzle out the situation presented in the problem, coming up with ingenious ways of solving those problems, and asking questions that prompt thought and discussion rather than a final answer.
Ultimately, he spends time during his teaching providing students opportunities to explore a variety of questions. Some of his questions require students to show a previously learned process, while other questions have no definite answer and focus on exploring a topic, leading to a concept that will be studied in the near future. Brad believes that:

one of the areas where students fall off with engagement is when there is only one route or solution; when students are unable to get that solution they become disengaged. Whereas, if it is an authentic inquiry, where they have to determine whether it is the right answer or not and accept that there are various routes to get there, students are more engaged. (Teacher Interview, Tuesday April 3, 2012)

For this reason, Brad utilizes the use of open-ended tasks and explorations in his teaching practice and is unafraid of challenging students to be engaged with the learning mathematics.

4.3.1.3 Meeting Individual Needs

Brad defined meeting the individual needs of students as “providing support for students to learn at their developmental level” (Teacher Correspondence, Monday October 8, 2012). He stated that teachers need to support students:

who have demonstrated that they are comfortable with the material or concepts that are being taught. As a teacher, you should be prepared and able to extend their thinking. Meanwhile, if students are not comfortable with the concepts, a teacher must be prepared to provide remediation and strategies to close the gap with the rest of the class. (Teacher Correspondence, Monday October 8, 2012)

Brad dedicates time both inside and outside of his classes to assist his students with what they need to learn mathematics. He differentiates his lessons for the various needs of his students through his classroom activities and the use of group work. He has also set a goal this past year to rework his notes “to include thinking or diagnostic questions, so students can develop clear and concise problem solving strategies” (Teacher Correspondence, Monday October 8, 2012). This goal encourages his students to make connections to previously learned topics and take ownership of their learning as it encourages thought, discussion and analysis.
For students who have difficulty with their graphing and motor skills, Brad copies either a set of student notes, or his own, to give to the student. If students are unable to process the knowledge at the same speed as the classmates, Brad prepares notes ahead of time. If the student has poor organization skills, he works with the student’s OneNote binder to assist them in the organization of their notes, homework and tasks. Brad will use manipulatives to help explain a concept or give students who need a kinesthetic tool to help understand the problem a way to represent the problem physically.

For students who struggle learning on their own, Brad arranges situations for students to work collaboratively in groups on a task so that a struggling student can feel that they are making a contribution to the smaller group, as opposed to being left out in a full class setting. He uses real-life problems that relate to the students and their age group so that they can see the validity and connection to what they are learning in class.

Brad’s desire to help his students succeed is evident in varied approaches he has to meet their individual needs. He works to ensure that, regardless of their developmental level and their mathematical ability, they are able to learn and enjoy learning mathematics.

4.3.2 Keith

Keith has been teaching for 8 years and completed his Masters of Education at Simon Fraser University in 2011. Keith had originally gone into the business field, however, when he found the corporate experience to be an empty one for him, he followed his passion for international development, specifically to work with and educate youth. Eventually, the traveling became exhausting and, as he has started a family, he has opted to settled into a more stable teaching role. Keith’s two main goals for his students are critical thinking and application. He wants “them to question everything they hear, not in a bad way, but [to] think about what they
hear and weigh it against what they have learned and make informed decisions” (Teacher Interview, Thursday April 5, 2012). He hopes his students will use what they know and apply that knowledge well, so that “they have options at the end of their high school career” (Teacher Interview, Thursday April 5, 2012). He uses these goals to drive the methodology and creativity in his mathematics classroom.

When overviewing Keith’s results to the Attitudes and Practices to Teaching Math Survey (Appendix B, February 3, 2012), I noted that he obtained an overall score of 4.316 out of six. It is apparent from his responses that he has a very strong attitude and comfort level with teaching mathematics and strives to encourage it within the students in his class. However, there are some areas where his teaching practice is more traditional.

**4.3.2.1 Technology**

Having just completed his Masters of Education degree and his work on the role of Interactive Whiteboards in mathematics, Keith is extremely keen to remain up-to-date with the changing technological world. He subscribes to many mathematics and education blogs in an attempt to be current with his information. Keith is always sharing resources with his department colleagues including articles in the newspaper and showing real-life application to new software that will make instruction and assessment easier, faster, or more interesting.

Keith believes that the purpose of technology in the classroom is to enhance the delivery of the content, the methodologies that are implemented and the tasks that can be created. He states:

The use of laptops and or tablets in the classroom is positive if it makes what I do and how my students learn in the classroom better, not the same, but better. Before I incorporate any technology, I look to see what it adds to my teaching and my students’ learning. It is not just about using the laptop and or tablet as a chalkboard or for taking notes. There must be more to it. This means that [teachers] need to do things differently and need to invest the time to do things differently. (Teacher Interview, April 5, 2012)
Keith’s current technological endeavor is the flipped classroom. The concept of a flipped classroom is a reversed teaching model that delivers instruction at home through interactive, teacher-created videos and moves “homework” to the classroom. Keith spends time creating videos that contain explanations of mathematical concepts as well as examples. He uploads the videos for his students both into their OneNote binders and onto Blackboard to watch at home. Students are able to watch it at their own pace, pause the video while they attempt the skills on their own, and may even replay if they need to hear the explanation again for further clarification. Keith’s students now have more opportunities to ask questions and work through problems during the class. They can work individually or collaboratively and Keith can circulate around the class spending more one-on-one time with each student or take time out of the work period for a class discussion about a challenging question or about a real-life application problem.

During a classroom visit, Keith started the class with a review question. He used an online resource named GoSoapBox (http://gosoapbox.com/) that is similar to an online quiz tool. It allows Keith to create questions for his students to answer, which can be directly from the lesson or similar to the lesson. He provides them with a timeframe in which to answer the questions and can immediately gather feedback on how his students answered the questions. He can also identify gaps and target where the misunderstandings and misconceptions are, so that he can revisit them during the class discussion.

Keith’s personal teaching goals for the year also included incorporating Gizmos (http://www.explorelearning.com/), which are interactive online simulations, and Geometer’s Sketchpad (http://www.dynamicgeometry.com/) used to illustrate and model mathematical
concepts. His use of these and other online resources is based on his premise that it should enhance what he is teaching and doing in the classroom and should benefit student learning.

His fellow department members value his knowledge of what is new and current as a means of enhancing their teaching as well. Keith’s major obstacle, however, is his own student’s view of teaching and learning. Often, he faces the challenge that they do not like the flipped classroom model that he is using because they are so used to being taught in a teacher-centered class. The model requires that students learn to manage their time wisely, so that they can watch the instructional video before attending class. This can be a challenge for students who are unable to balance their time well or who exist passively in the learning environment.

4.3.2.2 Student Engagement

Keith’s perception of student engagement is “when you have a class who is interested in what they are learning, they are active participants in the class and not simply passive participants.” Keith does not want his students to “just take notes, but to ask questions” (Teacher Interview, April 5, 2012). Essential aspects of active learning are both the “critical thinking and communication aspect.” This means that students “are not just passively absorbing it, but are actively listening to what is being said, processing it, asking critical questions about the content” (Teacher Interview, April 5, 2012), the validity and value of it, as well as having a good grasp on the material and its application.

Keith asserts that consideration to student engagement of the class is always in the background of his mind, in the literature and online resources he reads. However, he also admits that it “requires a lot of planning and time. The engagement aspect gets dropped when pressed for time” (Teacher Interview, April 5, 2012). Keith feels that the monotony of teaching a class the same way every day will decrease student engagement. As a teacher, he is constantly trying
to change his approach to a lesson and incorporating different activities as well as other forms of media.

In order to change the pace of his teaching, Keith implements various alternative strategies. He plays videos relating to mathematics, particularly the topic of discussion in class that day, to immediately gain student attention at the beginning of class. During his lesson, he works to incorporate various activities – from virtual polls on the online website Understoodit (https://understoodit.com/) that measures student understanding in real time, to creating a task with instructions for students to explore a concept using Geometer’s Sketchpad.

This engagement “translates to application. If a student is engaged, [they are] going to apply [themselves], take in what is being taught, question and process it” (Teacher Interview, April 5, 2012). For Keith, student engagement is about conceptual understanding, being able to think critically about what is being taught but to also question the learning in order to gain a better understanding of the concept in the end.

4.3.2.3 Meeting Individual Needs

Keith’s understanding of meeting the individual needs of his students is based on “working to ensure understanding of all students and that material is presented in more than one way” (Teacher Correspondence, Monday October 8, 2012).

The mathematics learning environment in Keith’s classroom is based on the use of technology and various cooperative learning strategies. For example, during one class visit, Keith used a carousel approach where students were given the opportunity to work in small groups and solve problems together. The problems were of a difficulty level such that students would be challenged on an individual level and would need to work together and share ideas in
order to solve the problem. This meant that students needed to share ideas, discuss their thoughts and explain their rationale with each another. Keith commented after this activity that:

It is a good opportunity for students to work individually and seek guidance and assistance from their peers. The questions that they ask and the answers that they provide one another are entirely based on what they have understood of the material they have been learning. The clarifications that they seek from their peers are genuine and the dynamic is such that they are willing to assist one another and offer explanations so that everyone in the group can understand. The end goal that they have inadvertently and unconsciously decided on is that everyone in the group will understand the material. (Classroom Visit, May 29, 2012)

Keith’s flipped classroom is an example of his desire to meet student needs. His teaching videos enable students to choose the speed of their lesson, any repetition and also have time to complete practice questions. Keith believes that a flipped classroom model provides opportunities for his students to “think critically about what is on the screen or on paper” (Teacher Interview, Monday April 2, 2012). When his students critically analyze the information they are presented with as opposed to passively accepting it, his classroom is primed for discussion, enabling students to delve further into the topic or ask for clarification of any misunderstanding or confusion around the topic. In this way, Keith can walk around the classroom and address specific concerns as well as expand topics to incorporate real-world applications that students may not have noticed prior to the flipped lesson.

Keith works with technology and teaching strategies to ensure that his students understand mathematics. He designs his curriculum delivery to assist in the transmission of concepts, but also in creating future situations for analysis and discussion of mathematics in his classroom.

4.3.3 Sheila

Sheila has been teaching for 16 years. Her career began when she was told that she would make a good teacher because of her ability to get along with youth. Sheila describes her favourite
moments as those when a student’s “eyes brighten with understanding” (Teacher Interview, Monday April 2, 2012). Her main desire for her students is for them “to feel that mathematics has a role in their lives outside of the classroom” (Teacher Interview, Monday April 2, 2012). With this desire in mind, Sheila sets out to engage her students in the mathematics classroom.

When overviewing Sheila’s results to the Attitudes and Practices to Teaching Math Survey (Appendix B, February 3, 2012), I noted that she obtained an overall score of 4.474 out of six. Similar to Keith’s results, it is apparent that she has a very strong attitude and comfort level with teaching mathematics and strives to encourage it within the students in her class but does have some traditional views in some dimensions of mathematics teaching.

4.3.3.1 Technology

Sheila has struggled with reintegrating herself back into the technological environment after a one-year absence. Sheila is a proficient user of the SMART Board, which is a prominent feature in all of the school’s classrooms. Her notes have all been created using SMART Notebook and she has been determined to continue using them. However, as the school moves to a more tablet-based model, the SMARTBoard is quickly becoming obsolete.

With the introduction of the tablet for the majority of the Senior School teachers, and to students in Grade 6 to 9, Sheila’s technology skills have been challenged. She must learn several new software packages and online resources and utilize them in her teaching. Sheila’s fear is obvious in both the statements that she makes and her teaching practice. Sheila is struggling to use the OneNote software that her colleagues are using proficiently. During her interview, Sheila commented:

[I am] not 100% sure I entirely grasp [OneNote]. I understand the concept behind it. It is like with anything new, when you are used to teaching the way you have done it for a long time, it is hard to envision how [OneNote] will make your life easier. I see how it is being used so I am incorporating it in baby steps.
It was noted during classroom visits that Sheila was still using SMART Notebook and has just started her attempt to switching to OneNote in September 2012.

Sheila noted that the incorporation of the laptop and or tablet in the classroom was best suited for “investigation and the exploration of ideas” as this provides students with a “visually accurate representation that they can work with, to discover the ideas themselves giving the results more meaning” (Teacher Interview, Monday April 2, 2012). Working in such a fast-paced world requires that teachers stay current, not only with students’ interests, but also in the methodologies that can be used to teach them. Fear is a natural part of life, however, teachers must learn to set aside that fear and embrace the new possibilities that technological change brings to the classroom.

**4.3.3.2 Student Engagement**

Sheila’s idea of student engagement is when students are an active participant in the class, “asking questions, volunteering answers, and being a member of the class” (Teacher Interview, Monday April 2, 2012). If students are not obviously engaged – raising their hand, answering questions, posing questions to the teacher – Sheila takes it as a potential sign that they do not understand the content. This lack of engagement is difficult to manage when it begins to affect the entire class, so teachers need to work constantly at keeping their students engaged.

**4.3.3.3 Meeting Individual Needs**

Sheila believes that meeting individual needs of students is two-fold: “ensuring the students have the tools that will enable them to grasps the concepts being taught and making sure that the learning environment and/or activity provides opportunities to allow all students to find understanding” (Teacher Correspondence, Monday October 8, 2012).

An 80 minute lesson is never ideal, so Sheila suggests having:
a diversity of how you teach something – some kids are very visual learners so get them at the board doing things, some kids are kinesthetic so you want to get some movement if you can but can be a bit challenging in math class. You try to vary your activities. (Teacher Interview, Monday April 2, 2012)

In Sheila’s class, she begins each lesson with a warm-up activity. The purpose of the activity is to refresh students’ minds about what was covered in a previous class or in the past few classes, but also to prepare them for the lesson ahead. She puts two or three questions on the board and lets the students work on it. They are encouraged to work individually at first and then may confer with a partner. Sheila circulates around the classroom and poses questions to prompt students to think and reason through the problem. Once everyone has had an opportunity to try the warm-up problems, she encourages a classroom discussion where the students are responsible for ensuring understanding among the entire class. Sheila’s use of these strategies display her role as a facilitator of learning to her students.

Sheila works to ensure that the learning environment she creates is one in which her students feel comfortable learning, because she gives them opportunities to contribute to and participate in it. She also works to differentiate her instruction so students receive the content in various forms and can associate to the type of learning best suited to their needs.

4.4 Summary

Educational trends are constantly changing, ever more rapidly now with the use of technology. Educators with many years of experience will describe the trends as a pendulum that swings back and forth. A wide array of strategies and methodologies can be implemented sometimes repeatedly and other times through a different perspective. Teachers must always be looking for ways to improve their teaching practices. Despite all the change, the essential focus remains – to build a strong mathematical foundation in students. A caring teacher who uses a
variety of strategies and techniques, in a positive learning environment, to ensure that each individual student has a learning experience that works for them, must build this foundation.
5.1 Introduction

In this chapter, I revisit the research questions posed in Chapter One and explore how the case studies of three secondary school mathematics teachers, Brad, Keith and Sheila, help to answer those questions. Next, I discuss the major findings of the study and link them to the current literature. Finally, I suggest areas for further research in the realm of meeting individual needs in a mathematics classroom with laptops and tablets.

5.2 The Research Questions

I explored how secondary school mathematics teachers utilize a laptop-classroom environment to meet the individual needs of students. My thesis focused on the research questions posed in Chapter One. Those questions were:

1. How can mathematics teachers adapt their teaching practice in order to integrate the laptop into daily mathematics instruction?
2. How does the implementation of laptops meet the individual needs of students?

5.3 Discussion of each Research Question

5.3.1 How can mathematics teachers adapt their teaching practice in order to integrate the laptop into daily mathematics instruction?

The case studies conducted for this research provided situations and experiences with respect to their integration of the laptop and/or tablet into the teaching practice. Each of the teachers in this study is a capable professional who has a goal of fostering mathematical learning and critical thinking. Each teacher must accomplish certain criteria in order to yield opportunities to meet the needs of students in a technological learning environment.
5.3.1.1 Role of the Teacher and Impact on Students

Many classrooms contain students who want the final answer, who want to take shortcuts, or who have no desire to think. These same students rarely make necessary connections without any form of prompting. The participating teachers see themselves as guides in their students’ journey of gaining mathematical knowledge (Gorder, 2008). One of the many roles of a teacher is to encourage critical thinking – to ask questions and pose problems that require students to make the appropriate connections so that they can develop their mathematical understanding and can expand their thinking to unfamiliar situations as well as ones that are not related to mathematics.

There should also be a focus on using the correct terminology to communicate mathematically, showing all steps in the work to demonstrate mathematical understanding and, applying skills learned to real-life situations. Two of the most effective methods of encouraging and building these skills identified in this study are through teacher modeling and questioning. The teachers used situations that included helping students to learn a new mathematical formula; when the students were unclear on its purpose or components, or students were having difficulty coming up with strategies on how to solve a problem, these teachers chose to model one strategy to get them started or demonstrate one way to tackle the problem (Zack & Graces, 2001). They also used questions to prompt students to think creatively to seek alternative methods or applications.

The third method these teachers used is to have class discussions where students shared their ideas about how to tackle a challenging problem. This prompted communication among students, the sharing of ideas, as well as a strong sense of ownership in their learning. This student-centered environment strategy is very empowering to students, giving them a strong
sense of their own thinking, creativity and place in the classroom. It also highlights the role of
the teacher as a facilitator.

Each case study participant has been involved in professional development opportunities
that work to clarify their beliefs as an educator and reflect on their practices. As such, each
teacher is cognizant of his or her role as a teacher in the classroom and has come to realize the
effect that he or she has on students. Each teacher is acutely aware of their position as a role
model, both of social cues and behaviours as well as the modeling of mathematical
understanding, critical thinking, and communication.

Sheila set up a classroom routine that evolves as she builds a level of familiarity with her
students and recognizes who they are as individuals and as learners of mathematics. She
observes how they learn alone and with others. She is cognizant of these learning styles and how
they integrate into group dynamics. She attempts to maximize students’ academic potential and
minimize their emotional stress during their time in her mathematics classroom, a finding which
supports those of Owens et al. (1998).

Keith works to create learning situations where students can make their own connections.
He recognizes that new concepts may be challenging; however, with support from the findings of
Zack and Graves (2001), he guides his students in their learning. Depending on the topic, he may
provide steps that lead them from an unfamiliar abstract concept to a more concrete and familiar
one, connecting their current understanding with prior knowledge as suggested by Alagic (2003).
Keith encourages student risk-taking and critical thinking by modeling questioning skills that
promote the phrasing of questions to yield new connections and understanding.

Brad works to foster mathematical understanding by giving students a variety of
strategies. He creates a virtual learning environment based on organization and structure. He
utilizes software such as IXL and online gaming from various websites to encourage skills practice among his students. He uses the technology to enhance his teaching and to develop a stronger mathematical understanding through practice of the concept via varied technological avenues.

These case study participants are examples of educators who are constantly striving for continued improvement in their teaching pedagogy. Each teacher works to create an environment that nurtures risk-taking in mathematical learning, model critical thinking, and utilize the laptop and/or tablet to enhance the student experience by meeting his or her individual needs.

5.3.1.2 Student Engagement

A mathematics teacher has the foundational aim of providing their students with a basic understanding of mathematical concepts. In addition, mathematics teachers would like their students engaged in class and beyond, to take their knowledge and apply it to real-world situations.

The mathematics teachers in this study strive to work with students who are able to comprehend the concepts presented and can apply them to a variety of situations. This construction of knowledge is key to their role as facilitators of learning. These teachers utilized a variety of teaching strategies to enhance student learning and keep students engaged.

5.3.1.2.1 Engaging Lessons

Teachers must create and execute lessons that engage students enabling them to take ownership of their learning and facilitate a deeper understanding of learning. When teachers create lessons, they carefully select the types of activities used to promote learning, while attempting to maintain student attention, without wasting time with ineffective activities. There is a fine balance to ensuring that activities are effective and useful to student learning.
These teachers used group work as a method to change the style of delivery of content in the math classroom and to promoting student learning. Students are social beings and should be encouraged to talk and share their mathematical learning. The teachers found that group work also helps students who struggle when working alone. Weaker students, who have problems making the connections on their own, tend to be grouped with two or three students of varied ability. This is done with the hope that knowledge can be shared amongst group members. The teachers noted that, using group work, the students explore the mathematics, share their insights, and explain to each other in words that they understand, without making concepts overly complicated (Vygotsky, 1978).

The teachers found that another method of making lessons engaging is using video clips and simulations to introduce a topic, demonstrate an example, or provide a thought to digest later. YouTube (www.youtube.com) is a fantastic resource for these types of videos, as are BrainPop (www.brainpop.com) and Khan Academy (http://www.khanacademy.org/), as well as investigations and online simulations available through Gizmos (www.explorelearning.com). Resources on the Internet are endless; however, these teachers found that they must sift through and determine the value that the resources add to the lesson.

Though it is imperative that teachers create engaging lessons for students, it is necessary to not lose sight of the key skills being taught and the application of those skills to the everyday world.

5.3.1.2.2 Positive Reinforcement

Part of the role of a teacher is to create a positive learning environment. Modeling encouraging behavior by giving praise to students and focusing on positive learning outcomes helps develop a good sense of self in a mathematics classroom.
Owens et al. (1998) propose that praise is a positive motivator for students. Positive reinforcement encourages students to make progress on otherwise difficult concepts. When students are attempting to make connections and they receive positive feedback, it enables them to reflect on what they have done well and learn mathematics in the process.

In Brad’s class, he often high-fives his students when they make a positive remark or make a connection that he was leading them toward. Since Keith and Sheila’s students tend to be older, they often foster positive behavior amongst the students and show their pleasure when students gain a good understanding of a difficult concept.

One of the key concepts in the IB Learner Profile is for students to be risk-takers. Brad, Keith, and Sheila all work to create environments where students feel safe to take risks with their learning; this means they encourage students to think outside of the box, to push the boundaries of what they know, and to apply their knowledge to new situations, knowing that positive outcomes will be reinforced.

5.3.1.3 Enthusiasm for Professional Growth

Regardless of the number of years teaching, a strong teacher is constantly looking for ways to improve their classroom environment and dynamics, content delivery, and ability to assist every student in the class. Brad, Keith, and Sheila are often seeking out professional development opportunities to improve their teaching practices and learn new teaching strategies that they can use to help their students learn mathematical concepts more efficiently and effectively.

For example, Brad attended a 3-day OneNote workshop at a neighbouring school. He entered the workshop with very little understanding of how utilizing the OneNote software would completely alter and enhance his mathematical instruction in the classroom. As previously
noted, at the end of the workshop, Brad returned to school extremely excited by what he had learned and the potential he now had to enhance his classroom. Brad uses the software every day for multiple aspects of student learning. He teaches students, especially intermediate aged students, how to structure their virtual binder; this includes the use of virtual lined or graph paper to assist in conveying mathematical form and communication. He encourages his students to implement various note-taking strategies, including highlighting, symbols and sidebar notes, to enhance the student learning experience. Students are encouraged to use and adapt the strategies provided to find the ones that work best for them.

Brad is also keen to share his learnings with the other colleagues. He models examples of how he has utilized the software and is patient in explaining the steps to anxious colleagues. Brad is also part of the spearheading movement at the school that is encouraging all subject teachers to transition to using Microsoft OneNote as a teaching, marking, and project tool. This endeavour is just one example of how a professional development experience can yield extremely worthwhile results.

Keith, on the other hand, connects to various social media sites and online communities that encourage the use of technology in the classroom and offer suggestions and strategies for its use. Keith has worked to incorporate the flipped classroom model and immediate response feedback (www.understoodit.com) into his teaching. The flipped model has provided benefits to students of varied levels, enabling them to learn at their own pace at home through videos Keith has made, but also provides time for learning moments in class that stem from curiosity, interest, and even misunderstandings. The immediate response feedback system enables Keith to pose a question to his class and immediately recognize whether they understand the concept he is explaining or if they need more information, additional examples, or another approach to the
topic. Using these tablet technologies, Keith is able to use his own learning to enhance the experience his students are having in the mathematics classroom.

These teachers are continually re-educating themselves in order to update their skills and stay current with the various methodologies for the enhancement of student learning, a finding which supports those of Desimone et al. (2002). This journey continues for each teacher, regardless of the number of years that he or she has been teaching. It is also a positive sign for teachers when they supported by colleagues and administrators in the school.

As educators, Brad and Keith have a clear goal and it parallels Guskey’s (2000) notion that professional development needs to be intentional. They both understand who they want to be as teachers and seek out opportunities to assist them with this goal. Their ability to meet the individual needs of their students has changed dramatically as they have used different strategies and implemented various technologies available on the tablet.

5.3.2 How does the implementation of laptops meet the individual needs of students?

The case study participants implemented laptops and/or tablets in their mathematics classrooms with the purpose of meeting the individual needs of students. Each student is unique in his or her journey of understanding. Whether they have been at the school since grade 1 or have just arrived at the beginning of the school year, students enter mathematics classrooms with varied ability. Students are rarely working at the same difficulty level or the same speed. Often a concept that may come easily to one student will cause difficulty to another. The participating teachers know that some students will grasp concepts immediately while others will need time to digest the information. They know that some activities may spark enthusiasm and interest in one type of students but will not garner interest from another. The challenge to meet the individual
needs of students is sometimes daunting but always necessary to ensure student success. Each teacher incorporates strategies that they believe will help their students to succeed.

Brad, Keith, and Sheila developed a bathroom renovation project that prompted their grade 9 students to see how the mathematics that they were learning in class could assist them in the real world. The project had several facets and each focused on a particular style of learner, in an attempt to meet their individual needs. The project allowed students to take into consideration their own style and creativity with respect to their design. The more creative and visual students utilized their strengths in art to influence their design, either by hand or using modeling software, such as Google SketchUp. There was experiential trip to the hardware store that enabled auditory learners to listen and interact with sales people who worked in the various departments. Kinesthetic learners had the experience of walking down the aisles and pricing out materials while in the store. The project was designed so that, regardless of a students’ strengths and weaknesses with respect to mathematics, the task was differentiated enough that each student had the ability to succeed. Students used OneNote software to make their calculations, maintain and update their design specifications, and submit their project for grading.

The teachers felt a strong sense of responsibility in their careers – to educate youth and prepare them for the future. They believed that no student should feel that they are unable to learn or to succeed. It is the role of the teacher to deliver material using a variety of strategies and methods to ensure that the needs of individual students are met.

5.3.2.1 Customized Learning Environment

These teachers work in an environment that is conducive to learning mathematics using the laptop and/or tablet. Perhaps one of the most important factors in eliciting participation and student engagement in a laptop and/or tablet classroom was by attempting to have students be as
knowledgeable and proficient as the teacher in the use of the laptop and/or tablet. Each case study participant modeled proper use of the laptop and/or tablet in the classroom. The laptop and/or tablet were a necessary component of the learning environment and not just an add-on. Teachers need to gain an awareness of what technology can offer to the classroom, have opportunities to explore technology integration, and reflect on how technology impacts their teaching.

Each student has his or her own laptop and/or tablet. Each student is able to customize their settings and create a virtual environment in which they are comfortable and enjoy spending time and learning. Students need to take ownership and use the technology in ways that will support their individual needs and accommodate learning styles. This should assist in building positive student attitude toward using laptops and/or tablets in the classroom as well as creating unique learning experiences that involve laptops and/or tablets (Newhouse, 1997).

Sheila was the only one of the three teachers who was not at the same level as the students, due to her absence the year before. While she liked what she was doing before much better, she was learning to adapt her former strategies to the new technology.

5.3.2.2 Providing Engaging Learning Opportunities

Students are naturally inquisitive and complete activities to feel successful. Tasks should be created with a student’s frame of reference and experience in mind, so that mathematical concepts can be linked around something of personal interest to them (Holton, Ahmed, & Williams, 2001; Moch, 2001; Vygotsky, 1978). Engaging tasks foster learning as they pique student curiosity in the topic and students become interested in finding out more. They will ask questions and critically analyze what is being presented as opposed to simply accepting the information as it is given.
In the classroom, Keith works to connect the mathematics in the flipped lessons with a relevant component in the real world. In this way, he shows how the concepts that the students are learning are not trivial and abstract, but rather, have application in their everyday lives. The students connect mathematics with real-world experiences and create associations based on the amalgamation of these two entities (Reys et al., 1998). By having more opportunities to utilize their mathematics, the students will have a greater chance of developing a rich mathematics understanding that can be applied outside of the classroom.

Brad’s students were exposed to a variety of strategies and experiences in his classroom, some of which came naturally to them and others not as much. However, it was important for the students to be exposed to a variety of tasks, including those with which they may struggle, so that not only are they able to find strategies that work best for them, but are also able to be open to new and different possibilities. The students learn more about themselves as learners, finding out their strengths, and hopefully improving their weaknesses, so that they become more well-rounded learners (Pape et al., 2003).

5.3.2.3 Cooperative Learning

Cooperative learning is a strategy that Brad, Keith, and Sheila implement to help their students to construct knowledge. When working with peers, students are exposed to opportunities to explore ideas that they may not have come up with on their own and to enhance an idea that they may have had with additions from other peers. This strategy enables students to explain their own understanding of the concept, thereby making them further rationalize their thoughts (Vygotsky, 1978; 1986). The case study teachers capitalize on Vygotsky’s (1978) zone of proximal development by putting their students in different groups to learn from as many people as possible.
Sheila converted a Grade 11 didactic lesson on the transformation of functions into a cooperative learning experience. Students logged into a GoogleDoc where they shared and applied their prior knowledge of transformations from the Grade 10 quadratics topic. This also provided an area for them to construct knowledge and discuss with others in the classroom about what the results were showing. The students were able to critically analyze their results and come up with concrete rules that could be applied to all functions. In this context, Sheila was able to take an active role as the teacher facilitator; she was able to monitor participation, track changes being made to the shared document, thereby making students accountable for their work, and gauge student understanding of the topic, addressing any challenges the students are faced with.

Through this activity, students had to take ownership of their learning and be involved in the process of learning. They shared and discussed ideas, sometimes ones that they may not considered themselves. This methodology also provided an opportunity for students to clarify their learning, though explaining their ideas or assisting a peer. By getting the students to express their ideas, the students had to organize and clarify their thoughts, creating a deeper understanding of the material (Alagic, 2003).

The virtual task created a sharing community, where the teacher was not the primary source of information. The students would not have synthesized the information as comprehensively by being told it by the teacher or learning it on their own. Each class member was responsible for contributing to the lesson in the form of graphing, discussion, recording results, or creating a summary of the activity. The learning also took on a community feeling, where students were all responsible for each other’s learning. Eventually, with continued efforts by everyone involved, students in Sheila’s classroom will celebrate not only their own successes, but that of their peers as well, similar to Zack and Graves’ (2001) findings.
5.3.2.4 Use of Laptop/Tablet

The use of the laptop and/or tablet is an important new tool that works to meet the individual needs of students in the mathematics environment. By incorporating a variety of strategies to learn mathematics on the laptop and/or tablet, students are given a variety of opportunities to create, experiment, and demonstrate their knowledge.

Using the laptop and/or tablet in the mathematics classroom enables it to be used as a tool to help understand abstract math concepts. Regardless of the age of the student, or their ability and proficiency using them, a laptop and/or tablet can be used as a tool for learning what is appropriate for them and can also grow to incorporate new skills when they are ready.

From a young age, students learn how to use computers in school, and as each new piece of software is added to their repertoire, students receive training on how to use it effectively in an educational setting. The teachers in this study believe that students must be presented with the various options for the technological learning environment, but must also be given the time to explore them, becoming comfortable with implementing them in various subjects. In this way, the use of the laptop and/or tablet is engrained in the way the student participates in class, learns, does homework, and offers reflections. Laptops and/or tablets become part of the whole learning experience.

In the tablet environment, teachers promote active learning in their students by teaching technological skills that allow students to search for, organize and analyze information, and communicate their findings through a variety of forms. Students are encouraged to work in a collaborative, problem-based learning environment that can take place physically, in the classroom, or virtually, online.
Students can also upload their assignments into a database where teachers can immediately check for plagiarism. Teachers can download the assignments, individually or as a class, grade them, and make comments directly into the document. The reviewed file can then be converted to a pdf document and sent back to the student providing immediate feedback. Students can also e-mail teachers for homework assistance and receive a timely response, as opposed to waiting for the next day or the next class to ask their questions or clear up any misunderstandings.

While some teachers believe that the laptop and/or tablet can act as a distraction for tentative or fearful learners, the laptop and/or tablet may also keep the attention of students who need assistance staying on task. The laptop and/or tablet has an interactive environment that can hold a student’s attention and still provide online opportunities to make connections and help him/her understand the mathematical concepts being presented.

In a laptop/tablet classroom environment, there will undoubtedly be periodic glitches. Technology will not always work when we need it or exactly as required (Gardner et al., 1994). The single most obvious consequence of a technological glitch is the immediate disengagement of the students. The teacher participants noticed that it is sometimes difficult to draw the students’ attention back to the lesson once the issue is resolved. When technology does not work properly, it takes away time from the lesson and student learning. However, it is imperative that both teachers and students are able to troubleshoot and fix issues or else seek immediate assistance from Information Technology personnel who work to support the technological classroom environment to minimize the risk of interruptions to the learning environment.

Using the laptop and/or tablet for learning, the teachers said that study and reflection provides students with various outlets for expressing themselves and demonstrating their understanding. Students can take notes, draw diagrams, research, answer online quizzes, type
their reflections in a blog, or make a video journal entry for the teacher to read. Students do not feel limited by the constraints of how they are able to communicate their learning and can experiment with different formats that will help them to grow as a learner. As students experiment with different communication forms, their choice of how they display their understanding of the concepts will deepen. They will be able to use their creativity to take risks and try other routes to solving their problems (Pape et al., 2003). This integration of the laptop and/or tablet in the teaching and learning environment makes for a technologically rich educational experience for students.

5.4 Major Findings

This thesis examined the teaching practice of three secondary school mathematics teachers as they used laptops in the facilitation of curriculum delivery, in order to meet the individual needs of students. The study showed that the teachers took many steps to create a learning environment that lead to the successful engagement of students and meeting the individual needs of those students.

The major findings of the case study can be summarized as follows:

1. Teachers are constantly seeking guidance and methodologies to improve their teaching pedagogy and enhance the learning environment so that it is more effective for students. If teachers are aware of their own learning style, they are better able to incorporate that understanding to enhance their teaching style. This leads to teachers needing to understand the purpose of incorporating laptops and/or tablets in their mathematics classrooms and experience how this will enrich the student learning experience. Technology training of teachers is necessary to improving the use of technological resources in the classroom. Teachers can develop the digital learning environment given opportunities to collaborate
with colleagues, to create and share resources, and reflect on their own successes and failures.

2. The teacher’s role in the classroom and the impact that he or she has on his or her students is important. The teacher acts as a guide to facilitate in the construction of knowledge and models appropriate learning behaviours, as well as organizational strategies and work-life balance, recognizing that their organization, facilitation, and presentation of content affects student motivation to learn. Another important and emerging facet of the teacher’s role is as a digital guide – teachers are crucial to delivering technology-enhanced curriculum, modeling the use of the laptop and/or tablet, and incorporating online resources in the classroom.

3. The classroom is a rich learning environment; however, it is no longer just the physical classroom containing desks and chairs but it has now expanded to incorporate the entire wealth of online resources and technological software providing cooperative and engaging learning opportunities. In this blended physical and online environment students feel safe to take risks with their learning and are intrigued by the subject material. Students are encouraged to take ownership of their learning, to share ideas with the classroom community, and to analyze and discuss relevant real-world connections.

4. Students receive a variety of engaging lessons and tasks that are relevant to their lives, eliciting dialogue amongst them. Differentiation in mathematics allows concepts to be taught broadly thereby appealing to a wide spectrum of learners encouraging them to think mathematically and not simply follow a memorized set of rules. Mathematics teachers who implement a variety of open-ended tasks have modified their teaching pedagogy so that all students have the ability to succeed at learning mathematics. Differentiated lessons and tasks are designed to give students multiple options for researching and processing information,
connecting to varied abilities, interests, and aptitudes, and providing opportunities for students to participate in and express their learning.

5. Laptops and/or tablets can be used in the mathematics classroom in various forms – from textbooks and online practice, to immediate response feedback and graphical analysis, to virtual cooperative learning environments. This technology helps to construct student knowledge that is more engaging, relevant, and meaningful, as teachers virtually expand their classroom and use laptops and/or tablets to facilitate students’ progression from concrete ideas to those that are more abstract and to real-world applications.

5.5 Implications for Further Research

Historically, mathematics education has largely been instructed and not constructed. Students would be taught a number of concepts and formulas. Perhaps they would receive some diagrams or data to analyze. With the increased use of technology, there has been a shift in this approach and students and teachers are being encouraged to learn and teach mathematics through exploration and discovery. The laptop and/or tablet, along with the accompanying mathematical software, provide a new avenue for students to discover and learn mathematics.

This study shows the dedication three secondary mathematics teachers have to create a laptop and/or tablet based learning environment that meets the individual needs of students in their classes. Each seeks out specific learning opportunities, creates an engaging classroom environment, and employs a variety of strategies that target different types and ability levels of learners. With all these factors in mind, further research can still be done to meet the diverse needs of today’s student community.

With the push for laptop and/or tablet only classrooms in a variety of settings, another area of additional research could be to examine whether or not the findings of this particular
study are effective with students with learning disabilities or behavioural problems. The present study offers strategies that should meet the needs of learners of varying ability level and types of learners. However, are there any additional considerations that need to be addressed in classrooms involving students with more specific or broad-ranging needs? Are these strategies appropriate and engaging for these types of learners as well?

This case study examines three secondary school mathematics teachers. Though they each provided valuable information and data for analysis, a future study involving middle school mathematics teachers would show the evolution of mathematical learning and processes as students age. A comparison of the practices from middle school to secondary school may highlight additional strategies that would prove useful in secondary mathematics classrooms or vice versa. At the secondary level, the concepts are even more abstract, so what tools can a middle school teacher use as a foundation for learning for these types of concepts? Could similar representational forms be used to scaffold a student’s mathematics learning, in order to prepare them for these later courses?

As a final suggestion, mathematics educators should consider more research on the “best practices” of technology integration. What is the best way to assist teachers in moving from weary technology users to facilitators and integrators of technology? Can a database of suggested resources, tools and lessons be created as a working document for new teachers to see how others have made the leap to incorporating technology in the mathematics classroom?

This study has provided information about how the laptop and/or tablet can be used in the mathematics-learning environment to meet the individual needs of students. Further research in this area will shed additional light on how to best meet the needs of our learners at all age, grade,
and ability levels and what strategies and considerations teachers should examine to promote satisfaction and success among mathematics learners.
References


Smith, L. M. (1978). An evolving logic of participant observation, educational ethnography, and
other case studies. In L. Shulman (Ed.), Review of research in education (pp. 316-377). Itasca, IL: Peacock.


Appendix A – Letter of Consent

Dear ___________________,

As you are aware through our informal discussions, I am a Master of Arts student at the Ontario Institute for Studies in Education, University of Toronto, and am studying the construction of individualized secondary mathematics knowledge using laptops for the purposes of my thesis. My thesis is about exemplary laptop teaching practices of Secondary Mathematics teachers and will specifically focus on the teaching strategies that teachers use to increase the incorporation of laptops to meet the individual needs of students. I believe that using laptops in the mathematics classroom will meet the individual needs of students thereby increasing their level of achievement. I believe that your knowledge and experience will provide insight into this topic.

My research data collection consists of three stages:

1. Preliminary interview
   This is a 45-minute interview that will be tape-recorded. I will ask you a series of questions about your teaching background, beliefs, goals and ideas about laptop use in the mathematics classroom, student engagement and success.

2. Classroom observations
   I will observe lessons on a monthly basis for 3 months and take notes on the teaching strategies used and student reactions. Prior to the lesson, I will ask you about what you plan to teach and the strategies that you will incorporate into your lesson. After your lesson, I will ask for clarification and reflections on the lesson that was taught.

3. Final interview
   This is a 30-minute interview that will be tape-recorded. I will ask you a series of questions about your involvement in the study, reflections on your own teaching and final thoughts about laptop use in the mathematics classroom, meeting the individual needs of students and student achievement.

I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the research has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be part of the study. The second copy is for your records. Thank you very much for your help.

Sincerely,

Researcher: Fatima Remtulla

Thesis supervisor: Dr. Douglas E. McDougall
Consent Form

I acknowledge that the topic of this research has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by Fatima Remtulla and agree to participate in the study the purposes described.

Signature: ______________________________

Name (printed): ________________________

Date: _______________________________
Appendix B – Attitudes and Practices to Teaching Math Survey  
(McDougall, 2004, pp. 87-88)

Instructions:
Circle the extent to which you agree with each statement, according to the A to F scale below.

Then, use the charts at the top of the next page to complete the Score column for each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Extent of Agreement</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I like to assign math problems that can be solved in different ways.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>2. I regularly have all my students work through real-life math problems that are of interest to them.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>3. When students solve the same problem using different strategies, I have them share their solutions with their peers</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>4. I often integrate multiple strands of mathematics within a single unit.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>5. I often learn from my students during math because they come up with ingenious ways of solving problems that I have never thought of.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>6. It’s often not very productive for students to work together during math</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>7. Every student should feel that mathematics is something he or she can do.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>8. I plan for and integrate a variety of assessment strategies into most math activities and tasks.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>9. I try to communicate with my students’ parents about student achievement on a regular basis as well as about the math program.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>10. I encourage students to use manipulatives to communicate their mathematical ideas to me and to other students</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>11. When students are working on problems, I put more emphasis on getting the correct answer rather than on the process followed.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>12. Creating rubrics is a worthwhile exercise, particularly when I work with my colleagues</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>13. It is just as important for students to learn probability as it is to learn multiplication.</td>
<td>A       B     C     D     E     F</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>14. I don’t necessarily answer students’ math questions, but rather ask good questions to get them thinking and let them puzzle things out for themselves.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. I don’t assign many open-ended tasks or explorations because I feel unprepared for unpredictable results and new concepts that might arise.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. I like my students to master basic operations before they tackle complex problems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. I teach students how to communicate their math ideas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Using technology distracts students from learning basic skills.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. When communicating with parents and students about student performance, I tend to focus on student weaknesses instead of strengths.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. I often remind my students that a lot of math is not fun or interesting but it’s important to learn it anyway.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Attitudes and Practices to Teaching Math Survey Scoring Chart

For statements 1–5, 7–14, and 17, score each statement using these scores:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

For statements 6, 11, 15, 18, 19, and 20, score each statement using these scores:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

To complete this chart, see instructions below:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Related Statements</th>
<th>Statement Scores</th>
<th>Sum of the Scores</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Program Scope and Planning</td>
<td>4, 8, 13</td>
<td>6, 4, 5</td>
<td>15</td>
<td>( \div 3 = 5 )</td>
</tr>
<tr>
<td>2. Meeting Individual Needs</td>
<td>2, 6, 7, 15, 16</td>
<td>( \div 3 = 5 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Learning Environment</td>
<td>3, 5, 6</td>
<td>( \div 3 = 5 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Student Tasks</td>
<td>1, 2, 11, 15, 16</td>
<td>( \div 5 = 5 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Constructing Knowledge</td>
<td>5, 11, 14, 15, 16</td>
<td>( \div 5 = 5 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Communicating With Parents</td>
<td>19, 9</td>
<td>( \div 2 = 2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Manipulatives and Technology</td>
<td>10, 18</td>
<td>( \div 4 = 4 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Students’ Mathematical Communication</td>
<td>3, 6, 10, 17</td>
<td>( \div 4 = 4 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Assessment</td>
<td>8, 11, 12, 19</td>
<td>( \div 4 = 4 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Teacher’s Attitude and Comfort with Mathematics</td>
<td>4, 7, 13, 15, 20</td>
<td>( \div 5 = 5 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Score (All 10 dimensions)</th>
<th>Overall Score (Total Score ( \div 38 ))</th>
</tr>
</thead>
</table>

**Step 1** Calculate the **Average Score** for each dimension:
1. Record the score for each Related Statement in the third column.
2. Calculate the **Sum of the Scores** in the fourth column.
3. Calculate the **Average Score** and record it in the last column.

For example:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Related Statements</th>
<th>Statement Scores</th>
<th>Sum of the Scores</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Program Scope and Planning</td>
<td>4, 8, 13</td>
<td>6, 4, 5</td>
<td>15</td>
<td>( \div 3 = 5 )</td>
</tr>
</tbody>
</table>

**Step 2** Calculate the **Overall Score**:
1. Calculate the **Total Score** of the sums for all 10 dimensions in the fourth column.
2. Calculate the **Overall Score** by dividing the Total Score by 38.

For example:

<table>
<thead>
<tr>
<th>Total Score (All 10 dimensions)</th>
<th>152</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Score (Total Score ( \div 38 ))</td>
<td>4</td>
</tr>
</tbody>
</table>
Step 3 Interpret the results:

<table>
<thead>
<tr>
<th>Average Score for Each Dimension</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average scores will range from 1 to 6. The higher the average score, the more consistent the teacher’s attitude and teaching practices are with current mathematics education thinking, with respect to the dimension. A low score indicates a dimension that a teacher might focus on for personal growth and professional development.</td>
<td>The overall score will range from 1 to 6. The higher the overall score, the more consistent the teacher’s attitude and teaching practices are with current mathematics education thinking and the more receptive that teacher will likely be to further changes in his or her practice.</td>
</tr>
</tbody>
</table>
Appendix C – Teacher Questions
Adapted from McDougall (2007)

Background Questions
1. What is your name?
2. What courses are you currently teaching and what is your role in the school?
3. How long have you worked at this school?
4. Where did you teach before and what courses have you taught?
5. How many years have you been teaching?
6. Where did you go to university?
7. Why did you become a teacher?

Mathematics
1. How would you describe your goals in mathematics?
2. How widely accepted are these views in the department? In the school? Among the parents?
3. How would you describe the provincial ministry’s vision of mathematics?
4. Which of the Ten Dimensions have you selected for your personal growth? Why were those dimensions selected?

School Culture
1. How do you create an environment which supports success in mathematics?
2. What challenges have you faced in trying to create a culture that supports student achievement in mathematics?
3. How do you work with staff and administration to develop the goals/vision of the school?

Versions of Success
1. For you, what counts as success for students in this school?
2. What are your goals for students in education?
3. How widely accepted are your goals with other teachers in the department? The school? Among parents?
4. In what ways do you see your goals for students reflected in your school’s mission statement?

Student Engagement
1. How would you define student engagement?
2. What can teachers do to increase student engagement?
3. To what extent do you consider student engagement when planning your lessons?
4. What effect does high and/or low student engagement have on other components of student life/learning?

Meeting Individual Needs of Students
1. How would you define "meeting individual needs of students"?
2. Would this definition change if I asked it in specific reference to math?
3. What do you currently do to meet the individual needs of your students?
4. What can you do as a teacher to increase your ability to meet the needs of students in your class?
5. To what extent do you consider the individual needs of the students in your classes when you plan your lessons?

Laptop Use
1. How often do you feel you utilize the laptop/tablet in your classroom on a daily basis?
2. What do you find yourself using the laptop/tablet for?
3. To what extent do you consider laptop use when planning your lessons?
4. To what extent do you involve laptop use when assigning homework or tasks?
5. What effect does high and/or low laptop use have on student learning and student life?
6. Provide at least 2 specific examples of how you feel laptops/tablets have improved mathematics instruction by meeting student needs in the mathematics classroom.

Challenging Circumstances
1. What are the most challenging things for you in this school as you go about your work?
2. Do you think this school is different from other schools in its challenges?
3. How would you describe the community of parents with whom you work?
4. How has the school context changed over the past few years, and what changes are going on now?

**Technology**
1. How do you incorporate technology in your classroom?
2. What is your opinion on technology in mathematics?
3. What are specific applications of technology (hardware and software) in your class?
4. What will you do to increase your use of technology?
5. How do you feel about the move from a laptop to a tablet environment?

**Overall**
1. What laptop/tablet programs or resources support success in mathematics outside of the classroom?
2. What do you think I should say in my report about how the use of laptop/tablet computers is impacting student learning and meeting the individual needs of students?
Appendix D – Teacher Recruitment E-mail

Dear Teacher Colleague (each e-mail will be addressed personally to each colleague),

I am a Master of Arts student at the Ontario Institute for Studies in Education, University of Toronto, and am studying the construction of individualized secondary mathematics knowledge using laptops for the purposes of my thesis. My thesis is about exemplary laptop teaching practices of Secondary Mathematics teachers and will specifically focus on the teaching strategies that teachers use to increase the incorporation of laptops to meet the individual needs of students. I believe that using laptops in the mathematics classroom will meet the individual needs of students thereby increasing their level of achievement. I believe that your knowledge and experience will provide insight into this topic.

My research data collection consists of three stages:

1. Preliminary interview
   This is 45-minute interview that will be tape-recorded. I will ask you a series of questions about your teaching background, beliefs, goals and ideas about laptop use in the mathematics classroom, student engagement and success.

2. Classroom observations
   I will observe lessons on a monthly basis for 3 months and take notes on the teaching strategies used and student reactions. Prior to the lesson, I will ask you about what you plan to teach and the strategies that you will incorporate into your lesson. After your lesson, I will ask for clarification and reflections on the lesson that was taught.

2. Final interview
   This is a 30-minute interview that will be tape-recorded. I will ask you a series of questions about your involvement in the study, reflections on your own teaching and final thoughts about laptop use in the mathematics classroom, meeting the individual needs of students and student achievement.

I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the research has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

This information presented in this e-mail will again be outlined in the Letter of Consent that you will be required to sign if you agree to be part of the study. A second copy of this Letter of Consent will be provided to you for your records.

Please contact me to indicate your desire to participate in this study. We will arrange a time to meet for you to sign the Letter of Consent and continue with the subsequent preliminary interview.

Thank you very much for your help.

Sincerely,

Researcher: Fatima Remtulla
Appendix E – E-mail indicating Research Intent to Parent of Child in Observed Class

Dear Parents,

The [School] encourages students to be life-long learners; at the same time, it also supports Faculty members as they endeavour to continually update their skills, bring best practices to the forefront of their teaching and excel at their own educational goals.

I am a Master of Arts student at the Ontario Institute for Studies in Education, University of Toronto, and am studying the construction of individualized secondary mathematics knowledge using laptops for the purposes of my thesis. My thesis is about exemplary laptop teaching practices of Secondary Mathematics teachers and will specifically focus on the teaching strategies that teachers use to increase the incorporation of laptops to meet the individual needs of students. I believe that using laptops in the mathematics classroom will meet the individual needs of students thereby increasing their level of achievement.

My research data collection will include observations of various lessons given by your child’s teacher for the next 3 months. I will be taking notes on the teaching strategies used and student reactions.

If you have any questions about the research being conducted, please do not hesitate to contact me.

Thank you very much for your help.

Sincerely,

Researcher: Fatima Remtulla  
Thesis supervisor: Dr. Douglas E. McDougall
Appendix F – Script to inform Students of Research Intent

Dear Students,

The [School] encourages students to be life-long learners; at the same time, it also supports Faculty members as they endeavour to continually update their skills, bring best practices to the forefront of their teaching and excel at their own educational goals.

I am a Master of Arts student at the Ontario Institute for Studies in Education, University of Toronto, and am studying the construction of individualized secondary mathematics knowledge using laptops for the purposes of my thesis. My thesis will specifically focus on the teaching strategies that mathematics teachers are using to increase the incorporation of laptops to meet the individual needs of students.

My research data collection will include observations of various lessons given by your teacher for the next 3 months. I will be taking notes on the teaching strategies used and your reactions to the methods they are using.

If you have any questions about the research being conducted, please do not hesitate to contact me.

Thank you very much for your help.

Sincerely,

Researcher: Fatima Remtulla
Appendix G – Letter of Administrative Consent

Dear Head of School,

As you are aware through our informal discussions over the past 3 years, I am a Master of Arts student at the Ontario Institute for Studies in Education, University of Toronto, and am studying the construction of individualized secondary mathematics knowledge using laptops for the purposes of my thesis. My thesis is about exemplary laptop teaching practices of Secondary Mathematics teachers and will specifically focus on the teaching strategies that teachers use to increase the incorporation of laptops to meet the individual needs of students. I believe that using laptops in the mathematics classroom will meet the individual needs of students thereby increasing their level of achievement. It is also my belief that the knowledge and experience exemplified by the teachers in the Mathematics Department will provide insight into this topic.

My participant recruitment consists of 2 stages:

1. **Teacher Recruitment**

   I will send out separate e-mails to members of the Mathematics Department to gauge their desire to participate in the study after our informal conversations.

2. **Letter of Consent**

   When a participant informs me of their desire to participate, I will have them fill out a letter of consent outlining their involvement. I will inform the participants that:
   
   - I will not use their name or anything else that might identify them in my written work, oral presentations, or publications. This information remains confidential.
   - They are free to change your mind at any time, and to withdraw even after you have consented to participate.
   - They may decline to answer any specific questions.
   - I will destroy the tape recording after the research has been presented and/or published which may take up to five years after the data has been collected.
   - There are no known risks or benefits to them for assisting in the project.
   - I will share with them a copy of my notes to ensure accuracy.

My research data collection consists of three stages:

1. **Preliminary interview**

   This is 45-minute interview that will be tape-recorded. I will ask the teacher a series of questions about his/her teaching background, beliefs, goals and ideas about laptop use in the mathematics classroom, student engagement and success.

2. **Classroom observations**

   I will observe lessons on a monthly basis for 3 months and take notes on the teaching strategies used and student reactions. Prior to the lesson, I will ask the teacher about what he/she plans to teach and the strategies that he/she will incorporate into his/her lesson. After the lesson, I will ask for clarification and reflections on the lesson that was taught.

3. **Final interview**

   This is a 30-minute interview that will be tape-recorded. I will ask the teacher a series of questions about his/her involvement in the study, reflections on his/her own teaching and final thoughts about laptop use in the mathematics classroom, meeting the individual needs of students and student achievement.
Please sign below to give your administrative consent allowing the research for this study to take place in the school and to have members of the Mathematics Department share their expertise for the basis of my research. Thank you very much for your help.

Sincerely,

Researcher:  Fatima Remtulla  
Thesis supervisor: Dr. Douglas E. McDougall

Consent Form

I acknowledge that the topic of this research has been explained to me and that any questions that I have asked have been answered to my satisfaction.

I acknowledge that members of my Faculty here at the school will be participants of the research of the study described by Fatima Remtulla in the letter above.

Signature: ________________________________

Name (printed): ___________________________

Date: ____________________________